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# ARCHIVES OF OTOLARYNGOLOGY

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## MÉNIÈRE'S SYMPTOM COMPLEX

Its Relation to Chemistry, an Etiologic Study

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SAN FRANCISCO

THE CAUSE of Ménière's disease is unknown, so say the wise men of the medical profession. It has been variously ascribed to disturbances of endocrine glands, infection, syphilis, low and high blood pressure, disturbances of the metabolism of salt, potassium, magnesium, iodine and calcium, deficiencies of certain vitamins (those responsible for spasm of blood vessels, as deficiency of thiamine, nicotinic acid or choline compounds), allergy, creatine-creatinine metabolism, and the action of the nondecarboxylated fraction of histidine-histamine. No one, so far as I know, has attempted to relate the disease to disturbances of nutrition and thus to body chemistry. This is the purpose in this paper.

### VITAMIN DEFICIENCIES RELATED TO MENIÈRE'S DISEASE

Since the appearance of the first edition of the work of Williams and Spies<sup>1</sup> on thiamine, in 1938, biologic and medical research have shown not only that degenerative changes occur in peripheral nerves but that, as Sure<sup>2</sup> aptly expressed it, "The Little Things in Life" have proved to be the big things in life and are helping to solve many of the complex problems with which man is beset today. In nothing has this been found more important than in Ménière's disease.

Covell,<sup>3</sup> studying the eighth nerve and the cochlea in rats, guinea pigs and chicks, showed that histologic changes of the nerve and its ganglion cells (both cochlear and vestibular) resulted from deficiencies of the vitamin B complex and that they sometimes occurred in lesser degrees in other deficiencies. Covell's studies were made at my suggestion when I was investigating the subject of nerve and conduction.

1 Williams, R. R., and Spies, T. D. *Vitamine B, (Thiamin) and Its Use in Medicine*, New York, The Macmillan Company, 1938.

2 Sure, B. *The Little Things in Life*, New York, D. Appleton-Century Company, Inc., 1937.

3 Covell, W. P. *Pathological Changes in the Peripheral Auditory Mechanism Due to Avitaminosis*, *Laryngoscope* **50** 632-647 (April) 1941, *Vitamins and the Ear*, *ibid* **51** 683-691 (July) 1941.

deafness Himwich<sup>4</sup> divided the vitamins into two groups those demonstrated to be necessary for the prevention of degenerative changes of the central nervous system and those not required for the maintenance of nervous structures In the first group he included thiamine (vitamin B<sub>1</sub>), nicotinamide, riboflavin, pantothenic acid and pyridoxine (vitamin B<sub>6</sub>), in the second, ascorbic acid and vitamins A, D and E Mellanby,<sup>5</sup> however, reported that definite degenerative changes were produced by vitamin A-deficient diets not only in the central nervous system but also in the eighth nerve and that these changes in the nerve were not, in the early stages, due to pressure of new bone in the modiolus or elsewhere in the internal auditory meatus Gladys Emerson,<sup>6</sup> of Evans' Laboratory, stated that the latter and his co-workers have found that changes occur in certain peripheral nerves in vitamin E-deficient guinea pigs As another bit of evidence that vitamin deficiencies play an important role in the degenerative changes of the nervous system, Wolbach<sup>7</sup> stated, "No one vitamin is concerned with the maintenance of myelin" Morsch<sup>8</sup> presented histories of 4 patients with typical symptoms of Ménière's disease who also had symptoms of deficiencies of both vitamin A and ascorbic acid He reported that an improvement was noted in the vertigo, tinnitus and deafness after intensive vitamin treatment

The relationship of the vitamin B complex and Meniere's disease has been widely reported in the recent literature Harris and Moore<sup>9</sup> were the first to report They were impressed with the peculiar dietary habits of people with this disease who were almost all addicted to diets in which vegetables or carbohydrates were preponderant and had an inadequate intake of protein They treated 20 patients with large doses of thiamine hydrochloride No result was observed Then they used nicotinic acid Again there was no result Finally they combined both treatments, giving thiamine hydrochloride, 10 mg, night and morning, and nicotinic acid, 50 mg, five times a day With this treatment there was entire relief of tinnitus in 10 cases and almost

4 Himwich, H E The Role of Vitamins in Brain Metabolism, *A Research Nerv & Ment Dis, Proc* (1943) **22** 33-41, 1943

5 Mellanby, E J The Experimental Production of Deafness in Young Animals by Diet, *J Physiol* **94** 380 (Dec 14) 1938

6 Emerson, G Personal communication to the author

7 Wolbach, S B Pathological Changes Resulting from Vitamin Deficiencies, *J A M A* **108** 7-13 (Jan 3) 1937

8 Morsch, P Vitamin Therapy of Meniere's Disease and Other Disorders Accompanied by Tinnitus and Vertigo, *Acta oto-laryng* **27** 629-637, 1938

9 Harris, H E, and Moore, P M, Jr The Use of Nicotinic Acid and Thiamin Chloride in the Treatment of Meniere's Syndrome, *M Clin North America* **24** 533-542 (March) 1940

entire relief in the other 10. Seventeen patients were entirely relieved of vertigo, and the other 3 had sufficient relief to be able to return to their work. Harris,<sup>10</sup> in a letter dated Feb 28, 1944, stated

We are still using thiamine hydrochloride, 10 mg, three times a day, and nicotinic acid, 100 mg, three times a day, for an initial period of five months. I find the vast majority are relieved of their dizzy spells in from two to six weeks, and as the vertigo subsides, the tinnitus decreases in intensity. As our series of cases progresses, and we now have over 500, I believe that the nicotinic acid with the marked peripheral vasodilatation caused by it, is the chief factor of their relief.

Guggenheim,<sup>11</sup> referring briefly to Meniere's syndrome, cited the finding of Somyngi that in allergic states there is depletion of potassium salts in the cells and increase of these salts in the body fluid and that the depletion is corrected through administration of potassium and insulin. He also mentioned a case in which petechial hemorrhages and presence of blood in urine and stool suggested the possibility that permeability of the stria vascularis, increased through deficiency of ascorbic acid, was a cause of Ménière's disease. He stated further that the most important agent in the prevention of neural degeneration in Meniere's disease is the vitamin B complex, i. e., thiamine and nicotinic acid.

Atkinson<sup>12</sup> contributed a thorough and satisfactory review of the subject. He concluded that allergy and histamine sensitivity accounted for 20 per cent of his cases and that the remaining 80 per cent, cases in which the patient was nonsensitive, were related to lack of nicotinic acid. In 69 of 108 cases data were available for analysis. Relief of vertigo was reported in 32 cases. He considered the disease the result of a constriction of the vascular supply. In a letter dated Feb 14, 1944, he wrote

I have just completed another paper on my results in 110 patients treated with nicotinic acid. In this series the tinnitus was removed entirely in 13 cases (12 per cent) and improved in 42 (40 per cent). Thus, in half the cases one can achieve an appreciable improvement in this symptom.

Cooper<sup>13</sup> emphasized the effects of choline compounds, which cause dilatation of the vessels supplying the viscera in mammals, and referred to Starr's report of relief of vertigo in 1 patient, suggesting that choline

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<sup>10</sup> Harris, H. E. Personal communication to the author.

<sup>11</sup> Guggenheim, L. Treatment of Deafness, *Laryngoscope* **50** 773-783 (Aug) 1940.

<sup>12</sup> Atkinson, M. Diagnosis and Treatment of Meniere's Disease, *Arch Otolaryng* **37** 40-53 (Jan) 1943.

<sup>13</sup> Cooper, M. J. Clinical Observations on the Effect of Choline Compounds in Neurological Disorders with Special Reference to Meniere's Syndrome, *Am J M Sc* **195** 83-88 (Jan) 1938.



compounds might be of value in the treatment of Ménière's disease. He reported that 6 patients who had taken methacholine chloride U S P by mouth showed definite improvement or complete disappearance of tinnitus and vertigo, especially if the drugs were taken prophylactically or during the period of attack.

Adams<sup>14</sup> related deficiency of ascorbic acid to asthenia and Ménière's disease, in both of which there are apt to be autonomic imbalance and vasomotor disturbances. He observed several cases in which ascorbic acid was absent from the urine, probably because of lack of this vitamin in the diet, and in which the condition was improved or entirely relieved by an increased intake of fruit and food containing ascorbic acid. He referred to O'Dell's suggestion that lack of this vitamin was a frequent cause of Meniere's syndrome. In several cases Adams used some of the factors of the B complex in addition to ascorbic acid.

Because the lack of sufficient amounts of the vitamins, particularly of thiamine, nicotinic acid, riboflavin, pantothenic acid and pyridoxine plays an important role in the aging process, one is justified in stating that Meniere's disease is a function of the aging process. Talbott and associates,<sup>15</sup> in a tabulation of 33 cases, showed that the patients were all 50 years old or older. In my studies, all the patients with eighth nerve deafness who were 40 years of age and over showed definite loss of high tones, severe in most of them. In all the cases the urine showed thiamine and nicotinic acid definitely low, in half the cases it showed porphyrin increased. When the eyes were checked for dark adaptation by Dr Evelyn Blanchard with her "reginometer," the results were out of line in nearly all cases.<sup>15a</sup> Many of the patients were 60 years of age and over. It should not be forgotten that the aging process frequently begins in early childhood and not infrequently before birth. Stieglitz<sup>16</sup> made the comment that premature development of the changes of senescence in one or more organs might well be caused by particular dietary deficiencies of the parents and that the geriatric, anatomic and functional changes of the thyroid, pituitary and adrenal glands may be influenced by heredity, by the nutrition of the parents at the time of conception and by the nutrition of the mother before and after birth. The far reaching effect of nicotinic acid deficiency, for instance has

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14 Adams, J. Ménière's Syndrome and Avitaminosis, *J Laring & Otol* **54** 256-258 (May) 1939

15 Talbott, J. H., Brown, M. R., Coombs, F. S., and Consolazio, W. V. Electrolyte Balance of Blood in Meniere's Disease, *Proc Soc Exper Biol & Med* **38** 421-422 (April) 1938

15a The "reginometer" is thought to be an improvement over the biophotometer in use at that time.

16 Stieglitz, E. J. *Geriatric Medicine*, Philadelphia, W. B. Saunders Company, 1943

been depicted graphically by Frostig and Spies<sup>17</sup> and others. Sebrill, of the United States Public Health Service, in his histologic study of Jukes's rats, deficient in pantothenic acid, stated that both the adrenal cortex and the gonads showed beginning atrophy of cells. It is interesting that a few human subjects whom two genitourinary specialists of San Francisco treated with large doses of pantothenic acid (100 mg daily intravenously) appeared to experience restorative effects in their flagging sex life.

The experimental dog, Benny, of Morgan and Simms<sup>18</sup> (fig 1) shows an aging process induced by dietary measures that may have a definite analogy to that of human life. At the age of 6 weeks this dog was restricted to a diet deficient in pantothenic acid, nicotinic acid and some other factors, unknown. He showed considerable irregularity of gait, especially in the hindlegs, suggesting some disturbance of the

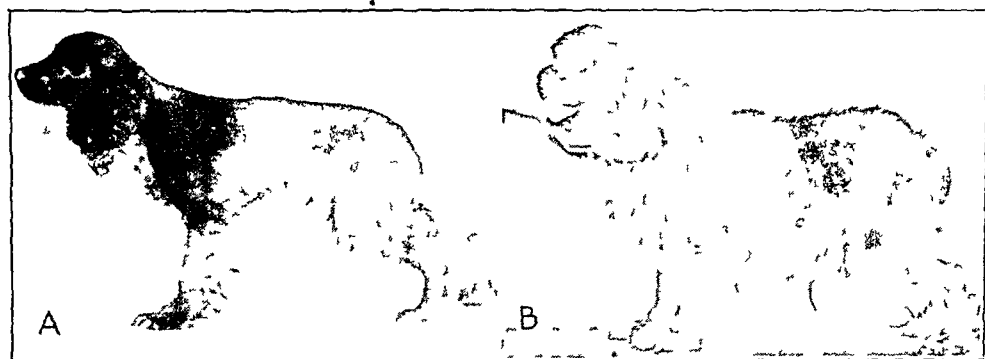


Fig 1—This dog shows the aging effect of a deficiency of pantothenic acid, nicotinic acid and other factors of the vitamin B complex. The experiment was reported by Morgan and Simms<sup>18</sup>.

vestibular apparatus. The aging process was evidenced by changes of posture, increasing grayness of hair, increasing ptosis of belly muscles and finally inability to stand erect. The dog died at the age of only 3 years, the average life span of a cocker spaniel varies from 8 to 12 years. Inasmuch as this dog's diet was normal except for the lack of pantothenic acid, nicotinic acid and some other factors, unknown, it seems obvious that the aging appearance and the pathologic changes are related to the missing factors. The autopsy report showed that the principal organ involved was the adrenal cortex.

17 Frostig, J. P., and Spies, T. D. The Initial Nervous Syndrome of Pellagra and Associated Deficiency Diseases, *Am J M Sc* **199** 268-274 (Feb) 1940.

18 Morgan, A. F., and Simms, H. D. Graying of Fur and Other Disturbances in Several Species Due to Vitamin Deficiency, *J Nutrition* **19** 233-250 (March) 1940.

This brings to mind the relation of pantothenic acid deficiency and fatty infiltrations and the possibility that the fatty substance may be cholesterol. Oakey<sup>19</sup> has already demonstrated that pantothenic acid is related to cholesterol in the production of dietary gallstones. It is known that choline is related to fatty livers and is a vasodilator substance, as is also nicotinic acid, hence these three substances may be definitely related to Meniere's disease, and perhaps to certain cardiovascular diseases. Certainly, these substances are present in inadequate amounts in some of the aging people whom I have observed in my studies of eighth nerve deafness.

#### ALLERGY AS A CAUSE OF MENIERE'S SYNDROME

Grove<sup>20</sup> has given the impression that most cases of Meniere's disease can be classified as cases of allergy. He stated that many patients present extra-aural symptoms: headaches, vasomotor rhinitis, chilly sensations, gastrointestinal symptoms, fatigability, insomnia and loss of memory and often have urticarias.

Dean<sup>21</sup> has shown a definite leaning toward allergy. He reported 2 cases. One patient was sensitive to several foods, which were removed from his diet. While this improved the vertigo, more complete relief was not obtained until the infected tonsils were removed. His second patient was sensitive to, *staphylococcus*. Injections were helpful but it was necessary to remove an infected adenoid and to correct a low basal metabolic rate with thyroid before a satisfactory result could be obtained.

#### AMINO ACIDS

Histamine is a noncarboxylated fraction of the amino acid histidine. Abandoned by its principal sponsors, Longcope, Haskin and Dwyer, of New York, it was resurrected, after nearly twenty-five years by Horton<sup>22</sup> before the Clinical Congress of the American College of Surgeons in Chicago in 1940 and has been written about favorably especially by Grove<sup>20</sup> and Atkinson,<sup>12</sup> in relation to Meniere's disease.

Recently Horton and associates<sup>23</sup> stated that they had used histamine successfully in a large series of cases of multiple sclerosis. It is their

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19 Oakey, R. Gallstone Formation and Intake of B-Vitamins in Cholesterol Fed Guinea Pigs, *Proc Soc Exper Biol & Med* **51** 349, 1942

20 Grove, W. E. Evaluation of Meniere Syndrome, *Ann Otol, Rhin & Laryng* **50** 55-69 (March) 1941

21 Dean, L. W., Jr. Meniere's Syndrome, *Internat Clin* **3** 231-234 (Sept) 1941

22 Horton, B. T. The Use of Histamin in Meniere's Disease, *Surg, Gynec & Obst* **72** 417-420 (Feb) 1941

23 Horton, B. T., and others. Treatment of Multiple Sclerosis by Intravenous Administration of Histamine, *J A M A* **124** 800-801 (March 18) 1944

opinion that the prompt improvement that follows histamine therapy probably results from the vasodilatation produced in the central nervous system. In the discussion of this paper, Wagener apparently questioned the findings, saying that the cases were followed for only fifteen months and that it would take at least five years to evaluate fully the effects of this treatment. Squier expressed the belief that with most allergic conditions histamine therapy would prove disappointing. He stated that he had seen 2 patients who had been given intravenous injections of histamine phosphate elsewhere and who had relapses during such therapy. These discussions show that medical opinions as to the value of histamine vary greatly but that the majority of physicians who have reported on the use of histamine do not consider that it tells the whole story.

Cordes<sup>24</sup> has shown that histamine can cause both arterial spasm and increased permeability of capillaries. He stated that histamine or histamine-like bodies circulating in the blood and their action on hyper-sensitive arterioles and capillaries can account for all the lesions usually attributed to cold, focal infection and allergy, that the pathologic changes are all due to spasm of smooth muscle and increased permeability of capillaries with resultant anoxia of capillaries and tissues. This constitutes further evidence that the reactions observed in the various allergies have fundamental causes other than protein sensitivity, which still remain to be identified.

#### INFLUENCE OF THE ELECTROLYTES

Mygind and Dederding<sup>25</sup> have advanced the theory that the symptoms of Ménière's disease, including tinnitus, are due to disturbance of the metabolism of water and that relief may be obtained by eliminating salt and water through perspiration and urination, stimulated by the use of pilocarpine or mersalyl. Tinnitus was not much affected. Cawthorne and Fawcett<sup>26</sup> reported that tinnitus, vertigo and, to a lesser extent, deafness were improved by diminishing the intake of fluids and that vertigo and deafness were made worse immediately when the intake of fluids was increased but were not greatly influenced by increasing the salt in the diet.

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<sup>24</sup> Cordes, F. C. The Use of Vasodilators in Acute Fundus Disease, *Am J Ophth* **26** 916-927 (Sept.) 1943

<sup>25</sup> Mygind, S. H., and Dederding, D. Clinical Experiments with Reference to the Influence of Water Balance on the Ear, *Ann Otol, Rhin & Laryng* **47** 360-369 (June) 1938

<sup>26</sup> Cawthorne, T., and Fawcett, J. Fluid Balance in Ménière's Disease, *Lancet* **2** 1404-1409 (Dec 17) 1938

Talbott, Brown, Coombs and Consolagio,<sup>15</sup> and in a later report Talbott and Brown,<sup>-7</sup> presented a careful laboratory study of the concentration of the acid-base constitution of the blood serum, including total fixed base, sodium, potassium, calcium, chloride, total carbon dioxide, phosphate, protein and nonprotein nitrogen. They expressed the belief that potassium salts are of far greater importance than sodium salts, which are implicated in the theory of Furstenberg, and that neither hydration nor alkalosis nor elevated serum sodium is a necessary accompaniment of Ménière's disease. Their chart indicates that the sodium-potassium ratio is definitely out of line, which should furnish a reason for their choice of therapy. They intimated that if the present laboratory methods of microbiologic and other studies of the blood for the members of the vitamin B complex (thiamine, riboflavin, nicotinic acid, nicotinamide, pantothenic acid, pyridoxine, biotin, inositol, para-aminobenzoic acid, adenylic acid, choline and folic acid), as well as for ascorbic acid and the tocopherols, were available much more would be known of the body chemistry.

Yoshiza treated tinnitus with magnesium sulfate. He made no mention of Ménière's disease, but Shick<sup>-9</sup> stated that these salts have a diuretic effect and exert an influence on the entire central and peripheral nervous system, affecting the vasomotor mechanism especially in the vestibular area. According to Sherman,<sup>30</sup> magnesium salts enhance the activity of the enzymes known as phosphatases and assist at certain stages in the metabolism of carbohydrates.

Little mention has been made of calcium being used in the treatment of Ménière's disease. Brunner<sup>31</sup> mentioned the use of calcium and iodine. In a letter dated Feb 16, 1944 he said that he still used them in tinnitus and thought he obtained results, however, he seemed somewhat doubtful. Apparently his use of these substances has been empiric and not based on any laboratory studies. The constant shifting of the electrolytes is such that many determinations would be necessary over a period of weeks before the true picture would be known.

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27 Talbott, J. H., and Brown, M. D. Ménière's Syndrome. Acid-Base Constituents of the Blood, Treatment with Potassium Chloride, *J. A. M. A.* **114** 125-130 (Jan 13) 1940.

28 Footnote deleted by the author.

29 Schick, A. Treatment of Ménière's Syndrome with Magnesium Salt, *Ann. Otol., Rhin. & Laryng.* **52** 45-51 (March) 1943.

30 (a) Sherman, H. C. *Chemistry of Food and Nutrition*, New York, The Macmillan Company, 1941. (b) McCance, R. A., and Widdowson, E. M. *The Chemical Composition of Foods*, Medical Research Council, Special Report Series, no 235, London, His Majesty's Stationery Office, 1940.

31 Brunner, H. Ménière's Syndrome, *Laryngoscope* **49** 877-911 (Oct.) 1939.

## THE ENDOCRINE GLANDS

Drury<sup>32</sup> observed in 568 cases of Ménière's syndrome that the pituitary gland was disturbed in 289, the thyroid gland in 148, the gonads in 119 and the adrenal cortex in 12. In the detailed study of 4 cases, classified as cases of Ménière's disease due to hypothyroidism, he gives an excellent exposition of the accompanying symptoms.

Werner<sup>33</sup> simply mentioned that tinnitus and vertigo may occur without causative lesions (no cardiovascular lesion). This is not an uncommon situation at the approach of, during and after the menopause.

Lisser,<sup>34</sup> in a letter dated March 28, 1944, stated

I have had a good friend, a man of 60 years, under observation in the last two years, who had had three characteristic attacks of Ménière's disease prior to getting established on a proper maintenance dose of thyroid. He had a low basal metabolic rate, although he had no obvious symptoms or signs of hypothyroidism. He required 5 grains [0.32 Gm] daily to maintain his rate at a normal level, and now for fully one and one-half years he has had no further attacks.

Selfridge<sup>35</sup> studied basal metabolic rates, hemoglobin content, intake of vitamin B complex, excretion of porphyrin (in urine), type of tinnitus and nature of catamenia in a series of patients with Ménière's syndrome. The basal metabolic rate was out of line in most of them. Most of the patients were markedly improved by the use of several vitamins, estrogenic substances and thyroid when these were indicated. A recent review of the subject indicates that pseudo Ménière's disease is not uncommon in younger persons, that it is often present in women during the menopause and that in the treatment of the latter the use of multiple tocopherols, as suggested by Spies, particularly in cases of non-organic tinnitus, is not to be forgotten.

Little has been said on the subject of amino acids and their importance in the general metabolic picture, but Holt,<sup>36</sup> in a paper presented at the Cleveland meeting of the American Chemical Society, in 1944, emphasized the importance of tryptophane, arginine, valine and methionine in warding off certain signs of senility, i. e., baldness, decay of teeth, anemia, cataract, permanent bloodshot appearance of the eyes, degeneration of the gonads in the male and reproductive failure in the female.

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32 Drury, D. R. Syndrome Complex, *New England J. Med.* **220** 170-173 (Jan. 24) 1939.

33 Werner, A. A. Ovarian Hypofunction and Afunction, in *Endocrinology: Clinical Application and Treatment*, Philadelphia, Lea & Febiger, 1937, pp. 239-240.

34 Lisser, H. Personal communication to the author.

35 Selfridge, G. Chronic Progressive Deafness with Special Reference to Estrogenic Substances, *Ann. Otol., Rhin. & Laryng.* **49** 52-55 (Aug.) 1940.

36 Holt, L. E., Jr. Elixir of Youth in Protein, *Science News-Letter*, April 15, 1944, pp. 252-253.

It has already been shown that the active chemical agents of the endocrine glands are proteins—amino acids—but the chemical formulas of the six active fractions of the anterior lobe of the pituitary gland are unknown. Much studying has been done but it may continue for generations before the formulas are worked out. The formulas of most of the amino acids and of the vitamins have been published, and the chemical setups of all foods and beverages have been published by Sherman<sup>30a</sup> and McCance and Widdowson<sup>30b</sup>.

It is agreed that the chemical actions, reactions and interactions occurring in the human body are controlled by the endocrine glands and that the pituitary gland, especially the anterior lobe with its six known fractions, controls all the other glands. The thyroid gland ranks first in the control of the metabolic processes, including that concerned with water, and the adrenal cortex appears to have a controlling action on most of the electrolytes and also on several of the vitamins. The gonads should not be ruled out, especially as the menopause approaches and emotional factors appear. Even at other ages of life tinnitus and sensations of dizziness are influenced by estrogens and also by androgens.

Carbohydrate when converted to dextrose is the most important chemical substance in cerebral metabolism. The first studies of this conversion, by Peters,<sup>37</sup> of Oxford, England, implicated thiamine as the principal factor in the process by which dextrose is converted through the intermediary of pyruvic acid to lactic acid but it is now considered that thiamine, riboflavin, nicotinic acid and ascorbic acid are the principal factors in carbohydrate metabolism, and this combination especially with choline added, is believed to influence fat metabolism also. In addition to this action on carbohydrates and fats, investigators are beginning to believe that these substances have an important influence on the vasomotor system. Long,<sup>38</sup> in his discussion of carbohydrate metabolism and its relation to the endocrine gland system, gave the definite impression that while the anterior lobe of the pituitary gland is the great controller, all the glands are involved in the process of carbohydrate metabolism. Elvehjem<sup>39</sup> pointed out that thiamine, as such, inhibits the action of cholinesterase, especially when the dosage of thiamine is at high levels. Thus, some of the symptoms associated with thiamine deficiency may be correlated with a decreased acetylcholine content of certain tissues of the body as well as with an increased pyruvic acid content.

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37 Peters, R. A. The Biochemical Lesion in Vitamin B Deficiency, *Lancet* **1** 1161-1164 (May 23) 1936

38 Long, C. N. H., in Duncan, G. G. Diseases of Metabolism, Philadelphia, W. B. Saunders Company, 1942, pp. 19-71

39 Elvehjem, C. Relationship of Enzymes to Deficiency. Nutritional Deficiencies, Baltimore, Williams & Wilkins Company, 1943

## WATER METABOLISM

This subject apparently is confusing, since Dederding and Furstenberg, and their groups, have held that Menière's disease is linked with water binding and sodium chloride, while Talbott and his co-workers have concluded that it is related to potassium salts. Goldzieher<sup>40</sup> pointed out that the actual requirements of the body and the amount of water retained are almost independent of the intake of water and yet are subject to both environmental and endocrine influences, and that the presence of such ordinary cell constituents as sodium salts, certain chlorides and carbohydrates is known to increase the avidity of the tissues for water. The posterior lobe of the pituitary gland plays a definite role in the control of water metabolism in cases of diabetes insipidus, and the thyroid gland has a definite part in the control of water and salt metabolism, especially in cases of myxedema. Likewise the adrenal cortex, often called the gland vital for life, has an important role to fulfil not only as a controller of water balance but also as the probable controller of several of the electrolytes—sodium, potassium and perhaps others. In addition, it has some influence on the members of the vitamin B complex and on ascorbic acid. Deficiency of pantothenic acid definitely influences the adrenal cortex, and Sebrell noted atrophy of the cortical cells as well as of the gonads. Gower<sup>41</sup> linked riboflavin, pantothenic acid and possibly some other vitamins of the B complex to water metabolism. Dr Marjorie M. Nelson, of the department of biological research of the University of California, told me that animals deficient in pantothenic or in nicotinic acid showed definite evidences of dehydration, and Lepkovsky, of the department of poultry research of the University of California, told me that animals deficient in pyridoxine were avid for water. These various findings are but suggestions that in Dederding's and especially in Furstenberg's cases the symptoms might have been controlled by other means than ammonium chloride and salt-free diets.

Tobey<sup>42</sup> closed an excellent review of the medical treatment of Menière's disease with these words:

It is apparent that studies in water and mineral metabolism have yielded definite results, and still offer a fertile field for investigation. Development in our knowledge of vitamins shows promise of increasing influence in the treatment of Menière's disease.

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40 Goldzieher, M. Biological Aspect of Constitution, A Research Nerv & Ment Dis, Proc (1933) 14 122-137, 1934

41 Gower, S. Water Metabolism, Proc Soc Exper Biol & Med 49 691-692 (April) 1942

42 Tobey, H. G. Medical Treatment of Meniere's Disease, Surg, Gynec & Obst 72 425-430 (Feb) 1941



## PSYCHOSOMATIC AND WEATHER PROBLEMS

Psychosomatic conditions and physical stresses imposed by changes of weather have a bearing on the subject of tinnitus, whether this occurs singly or as a symptom of Ménière's disease, and are mentioned by Fowler in his recent study of tinnitus, but with not enough emphasis, in my opinion, on the psychosomatic picture. Apparently, little attention has been paid to emotional factors in pseudo Meniere's and real Ménière's disease. Weiss and English<sup>43</sup> related tinnitus to anxiety states, sexual tension and disease of blood vessels, and stated that the tinnitus is vastly increased if there is any degenerative involvement of the eighth nerve, and that suggestive treatment is in order.

Kerr,<sup>44</sup> since World War I, has written at some length on anxiety states. He mentioned that patients suffering from anxieties presented symptoms and signs of tetany associated with hyperventilation. In a recent conversation he mentioned having seen several more cases of Meniere's disease since publishing his first article, and emphasized the need of a study of the acid-base balance in all cases. He expressed the belief that a large proportion of people consulting physicians since World War I and during the present world crisis are victims of anxiety states with symptoms that simulate those of serious organic diseases. Hence the study of psychosomatic medicine and geriatrics should be followed intensively by those really interested in improving the health and well-being of patients consulting otolaryngologists.

Another factor, and a potent one, influencing these psychosomatic conditions has been set forth in a convincing manner by Peterson and Mills. In 1934 Peterson<sup>45</sup> discussed at some length the season of the year and the effects of cold, and mentioned that in Meniere's original case the first episode occurred on Dec 28, 1860, and another on February 6, during the winter months. He considered further the relation of abnormal water balance and defective vasomotor function, hearing as affected by heat and cold and the close integration of Ménière's syndrome, migraine, epilepsy and psychoses. He seemed to think Ménière's syndrome is frequently initiated with meteorologically induced vascular spasm and that the acute attacks have a tendency to occur in the later winter and early spring months, when polar infalls (cyclonic types of weather) are apt to occur. The type of arterial

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43 Weiss, E., and English, O. *Psychosomatic Medicine*, Philadelphia, W B Saunders Company, 1943, p 475

44 Kerr, W J. Some Physical Phenomena Associated with the Anxiety States and Their Relation to Hyperventilation, *Ann Int Med* **11** 961-992 (Dec.) 1937, Treatment of the Anxiety States, *J A M A* **113** 637-641 (Aug 19) 1939

45 Peterson, W F. The Patient and the Weather, *Ann Arbor, Mich*, Edwards Brothers, 1934, vol 2, p 489

spasm referred to by Selfridge in two recent articles <sup>46</sup> is similar to the type due to polar infalls

Mills <sup>47</sup> told a fascinating story of the life of man as affected by climate and meteorologic factors and showed that the Chinese, because of the lack of cyclonic weather and because of a diet consisting largely of soybeans, do not have arteriosclerosis and coronary disease. He pointed out the various factors involving, in particular, the peoples of the United States. He stressed the observation that many symptoms in people, and bad moods and many actions of both animals and human beings are definitely related to "falling barometers." He stated that the exact mechanism by which such weather changes affect human beings in so many ways is not yet known, then he added

Peterson believes it is all due to a shifting chemical balance in the blood and body tissues. Other preliminary findings indicate that our tissues take up more water at such times, and a resulting slight swelling of the brain may upset us emotionally.

#### SUMMARY

I have repeatedly pointed out that deafness (and this includes Menière's disease) is not caused by any one thing but is related to all the factors involved in growth, i. e., endocrine products, electrolytes, amino acids and vitamins, including vitamin A. Guggenheim,<sup>11</sup> while he advocated that vitamins D and A be used along with ascorbic acid and the vitamins of the B complex in the treatment of other forms of deafness, did not advise that they be used in the treatment of eighth nerve involvement. Gladys Emerson<sup>6</sup> stated that Evans and his co-workers have shown that guinea pigs born of parents slightly deficient in tocopherol (vitamin E) and themselves quite deficient at birth apparently made a complete recovery, provided this factor was administered within fifteen days. In my experience, patients with eighth nerve deafness who had only a slight loss of high tones recovered the loss in a few weeks with the use of thiamine and nicotinic acid, whereas patients who had an abrupt loss in the audiometric curve did not show any recovery. Babbitt emphasized the well known fact that when the nerve is badly damaged the pathologic process cannot possibly be reversed by any use of endocrine substances, vitamins, electrolytes or amino acids. He mentioned the brilliant studies of Crowe and associates on the loss of perception of the higher tones in children due to tubal stenosis and stressed the importance of preventive measures (radium treatment of adenoid remnants), failure to treat such conditions in

<sup>46</sup> Selfridge, G. Arterial Spasm and Fat Metabolism. Their Relation to Certain Diseases and to Certain Members of the Vitamin B Complex, *California & West Med* 62 163 (April) 1945, *Ann Otol, Rhin & Laryng* 54 384-389 (June) 1945

<sup>47</sup> Mills, C. Climate Makes the Man, New York, Harper & Brothers, 1942

<sup>48</sup> Footnote deleted by author

children may mean high tone deafness in the aging period of life Babbitt made the statement that in the management of aging ears the three most troublesome conditions are deafness, vertigo and tinnitus, inevitably present in the complex Meniere's syndrome To all this I subscribe, bearing in mind, however, that all aged patients are not the victims of pseudo or real Meniere's disease and that a small percentage of those who suffer from these diseases can be relieved when the proper chemical therapy is worked out To determine deficiencies of the diet one must have a complete list of the foods eaten each day in a period of one week, detailing the quality and the quantity of each food In addition a thorough physical examination should be made, and the usual laboratory studies, including determinations of the blood levels of all vitamins, electrolytes and some amino acids A large part or even the whole, of the etiologic problem including the role of the adenoids, is definitely related to dietary deficiencies, which can explain the continued infection of this tissue Blockage caused by tubotympanic tissue is definitely related in many cases to riboflavin deficiency Covell<sup>3</sup>



Fig 2—These rats are about to have a definite attack of vertigo, the cause of which is a deficiency of thiamine

has shown that this blockage is present just at the point where the eustachian tube enters the middle ear I have noticed that in patients with this type of ear who also complained of stuffy nose and postnasal drip, mucoid in character, with no pus present, improvement followed administration of riboflavin (30 mg daily) or a vitamin B complex preparation with vitamin A and ascorbic acid added

Crowe, discussing an article by Altman and Fowler Jr,<sup>49</sup> mentioned having observed 1,000 cases of Menière's disease, and wrote, in an article in *Medicine*, that patients with this disease are extraordinarily free from general systemic disorders, such as cardiorenal disease, arteriosclerosis, focal infections and allergies He did not obtain satisfactory results with histamine and nicotinic acid and concluded that surgical division of the labyrinthine branch of the eighth nerve was the only procedure that offered relief from the terrible vertigo However, Talbott,<sup>15</sup> of the Massachusetts General Hospital, has not advocated

49 Altman, F, and Fowler, E P, Jr Histological Findings in Meniere's Symptom Complex, in Bothman, L, and others The 1943 Yearbook of Eye, Ear, Nose, and Throat, Chicago, The Year Book Publishers, Inc, 1943, p 403

surgical procedures since his adoption of the use of potassium chloride, and Davis, of the Cleveland Clinic, said in a letter of recent date that the neurologic surgeons of that clinic have not divided the nerve since the decision to try diets and administer thiamine hydrochloride and nicotinic acid in large doses over periods of months. Five hundred cases have been studied since their first 20 cases in which such treatment was given were reported in 1940.

In the laboratory studies of blood chemical and dietary deficiencies, pantothenic acid was determined by the method of Strong, Feeney and Earle,<sup>50</sup> riboflavin by the method of Snell and Strong,<sup>51</sup> and nicotinic acid by the method of Krehl, Strong and Elvehjem.<sup>52</sup> Other suggested laboratory procedures are the determination of the basal metabolic rate, the complete blood sedimentation rate, vitamin A and carotene, ascorbic acid, cholesterol, sulfobromophthalein sodium, chlorides, sodium, potassium, calcium, phosphorus, blood sugar, urea nitrogen and, when possible, choline-tocopherols, trace minerals, special amino acids and acid-base balance.

#### COMMENT

The principal treatments advocated for Ménière's disease are

- 1 Surgical section of the labyrinthine branch of the eighth nerve
- 2 Those related to the metabolism of salt and water
- 3 Those related to the metabolism of potassium
- 4 Those related to the use of certain vitamins, especially thiamine and nicotinic acid, nicotinic acid alone, and a member of the group of choline compounds (choline is now known as a fraction of the B complex)
- 5 Those related to the use of histamine

A review of the recent literature gives the impression that the most favorable results have followed the use of several of the vitamins. Apparently, since the use of electrolytes, vitamins or endocrine substances began, surgical intervention has lost its popularity. Since the vitamins and the endocrine substances are so closely allied, as shown by their chemical formulas, it hardly seems preposterous to make the claim that Ménière's disease is a chemical problem still requiring further study if and when more is known of the rare minerals and the recent, almost unknown factors added to the list of vitamins, and that it is related to nutritional and environmental factors.

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50 Strong, F. M., Feeney, R. E., and Earle, A. Pantothenic Acid Indust & Engin Chem (Anal Ed) **13** 561, 1941

51 Snell, E. E., and Strong, F. M. Riboflavin, Indust & Engin Chem (Anal Ed) **11** 346, 1939

52 Snell, E. E., and Wright, L. D. Microbiological Method for Determination of Nicotinic Acid, J Biol Chem **139** 675-686 (June) 1941

## FOREIGN BODIES OF THE EXTERNAL AUDITORY CANAL CAUSING OTITIS MEDIA

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FOREIGN bodies impacted in the external auditory canal or the middle ear may be of serious importance. Any object small enough to enter the external auditory canal is a potential foreign body in this location. Foreign bodies enter the external auditory canal by act of the person concerned, by carelessness and by accident. Small objects such as seeds, beads, rubber erasers from pencils, steel springs, balls of paper or stones may be placed in the ear by children at play. Adult persons in misguided therapeutic efforts scratch the external auditory canal with match sticks, toothpicks and hairpins. Cotton pledgets and gauze wicks placed in the external auditory canal by patient or physician may be forgotten and left in the canal, as may rubber ear plugs used by swimmers. One patient has been seen at the Mayo Clinic in whom a cast of plaster of paris became lodged against the tympanic membrane while an impression was being made for the ear piece of a hearing aid. Flying insects are the most frequent of the foreign bodies which enter the ear by accident. Workmen are subject to having flying bits of plaster, drops of paint, wood chips or small stones enter the ear. Gasoline or oil may enter the ears of automobile mechanics. Bits of straw and the seeds of foxtail grass are found in the ears of farmers. Cerumen that has become dry and hard acts as a foreign body.

The tympanic membrane is damaged by relatively few of the foreign bodies which enter the external auditory canal. Injury of the membrane results from (1) trauma inflicted direct by the entering foreign body, (2) caustic or irritating action of the foreign matter, (3) prolonged contact of the foreign body with the drum and (4) trauma incurred during attempts at removal of the foreign body.

### DIRECT TRAUMA

Perforation of the tympanic membrane occurs occasionally when the external auditory canal is scratched with a match stick or a similar object which is inserted too far into the canal. The extreme sensitivity of the external auditory canal is nature's best protection against this

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accident The sharp pain incident to perforation of the tympanic membrane causes immediate removal of the foreign body Inflammation resulting from this accident usually is slight and is confined principally to the drum Healing by first intention generally occurs without significant sequelae The curvature of the external auditory canal protects the tympanic membrane from being injured by flying foreign bodies unless the foreign body enters the canal with extreme force

#### CAUSTIC ACTION

Destruction of the tympanic membrane due to the caustic action of foreign matter in the external auditory canal causes severe damage of the structures of the tympanic cavity Two cases will illustrate this point

A man complained of bilateral loss of hearing He stated that he had placed a solution of phenol in each external auditory canal in order to escape duty with the German Army in World War I Examination revealed complete destruction of the tympanic membrane and other structures of the middle ear The tympanic cavities were lined with dense, glistening scar tissue Severe deafness of the conduction type was noted in each ear

A man stated that sludge from the bottom of an automobile gasoline tank had entered his left ear six years previously He had suffered immediate severe pain, followed by continuous drainage of foul pus from the ear and occasional headache and vertigo Examination revealed severe deafness of the conduction type A large polyp, which arose from a perforation in the posterosuperior portion of the tympanic membrane, filled the external auditory canal Roentgenograms were interpreted as showing the cavity of a cholesteatoma Radical mastoidectomy was performed A large cholesteatoma cavity was found, which exposed the dura in the temporal fossa The middle ear was filled with granulations, the ossicles were necrotic

Gasoline which enters the external auditory canal causes severe pain If the patient heeds this warning and has the gasoline removed within a few minutes, damage is limited to acute inflammation of the canal and the drum Prolonged exposure to the irritant may cause necrosis of the drum

#### PROLONGED CONTACT

Most foreign bodies cause irritation and pain This is fortunate in that the patient seeks the assistance of a physician, so that the foreign body is removed before the inflammatory reaction becomes advanced Living foreign bodies (insects) cause marked irritation by their movements, and are removed early Inanimate foreign bodies cause irritation by pressure However, foreign bodies sometimes are found which obviously have been in the external auditory canal for a long period, the patient having been unaware of them Cotton pledgets and small rolls of paper frequently cause no irritation Infection of secretions which cannot be discharged from the external auditory canal because of an obstructing foreign body results in otitis externa and myringitis,

and may cause perforation of the tympanic membrane by ulceration. Tightly lodged foreign bodies that prevent escape of secretions and desquamated epithelium may lead to the formation of cholesteatoma in the external auditory canal. This is illustrated by solid masses of cerumen covered by concentric layers of desquamated epithelium which cause necrosis of the tympanic membrane and tympanic ring to form the so-called natural radical mastoidectomy cavity. The following cases illustrate damage done to the tympanic cavity by various retained foreign bodies.

A soldier was admitted to a military hospital complaining of unilateral loss of hearing. Examination revealed a tightly impacted mass of cerumen which resisted removal by irrigation and curet. With the patient under the influence of general anesthesia, the mass was removed. It was surrounded by concentric layers of cholesteatoma which had destroyed the tympanic membrane and the ossicles and had eroded widely into the periantral region of the mastoid process. The facial nerve was exposed in the cavity, and was injured during removal of the mass.

A boy 7 years old complained of pain in the left ear of twenty-four hours' duration. A watermelon seed, which apparently had been in the external auditory canal for a prolonged period, was removed. The canal was inflamed, but the tympanic membrane was normal at the time the seed was removed. On the next day a bleb was noted on the tympanic membrane and was incised. Pain persisted and was accompanied by gradual development of myringitis and otitis media. Recovery occurred after myringotomy was done.

A boy 8 years old complained of fever and of pain in the right ear of twenty-four hours' duration. A kernel of corn was removed from the right external auditory canal. A perforation was present in the tympanic membrane, which was inflamed. Drainage from the middle ear persisted for two weeks, at the end of which the perforation healed.

A man 61 years old complained of itching and swelling of the ears of fifteen years' duration. He said that the right ear drum was absent. He had undergone much treatment without relief, and often he had scratched the external auditory canals with cotton until bleeding occurred. Examination revealed marked thickening of the skin of the auricles, conchae and canals of both ears. The external auditory canals were narrow. Foul-smelling pus was present in the right external auditory canal. Epithelial debris was present in the left. At the initial examination a broken piece of toothpick was removed from the right external auditory canal. Treatment by dressings kept wet with solutions of penicillin, sodium aspergillate and aluminum acetate did not produce improvement in the right ear. Radical mastoidectomy was performed on the right side. Chronic inflammation of the mastoid cells was found. A piece of string,  $1\frac{1}{2}$  inches (about 4 cm) long, was removed from the tympanic cavity. The patient had not been aware of the presence of either foreign body.

After the operation a cotton wick was placed in the patient's left external auditory canal. The patient returned later in the day complaining of sudden loss of hearing. The cotton wick had been pressed tightly against the drum medial to the isthmus.

#### TRAUMA INCIDENT TO REMOVAL

Foreign bodies which become lodged in the bony portion of the external auditory canal medial to the isthmus lie near or against the tympanic membrane. Removal should be achieved by irrigation if

possible, or manipulation should be carried out with the utmost care. If the foreign body is tightly lodged, the difficulty of removal is increased by swelling of the wall of the canal due to inflammation or to trauma from attempted removal. General anesthesia should be employed for the removal of tightly lodged foreign bodies. In some cases it is best to approach the foreign body through the mastoid process to avoid damaging the tympanic membrane.

A boy 7 years old was brought to the clinic because of a bead in the left ear which had been present twenty-four hours. A similar bead had been removed from the right ear. Attempts to remove the bead through the external auditory canal and through a postauricular incision had been unsuccessful. A probe had been broken off in these attempts, and the tip of the probe remained in the left ear. Examination revealed a recent postauricular incision on the left side. The external auditory canal was large, with little inflammatory reaction. Roentgenograms revealed a bead in the left external auditory canal, medial to the isthmus. A small bit of metal lay below the bead.

With the patient under general anesthesia, the bead was manipulated, engaged with forceps and removed through the external auditory canal. A small bit of metal, the tip of the probe, was found embedded in granulations in the region of the eustachian tube. The malleus was clearly visible after removal of the foreign body, indicating destruction of the tympanic membrane. Because of loss of epithelium from the wall of the external auditory canal at the isthmus, a rubber tube was left in the canal to prevent atresia. The patient was able to hear a low conversational voice in the left ear after removal of the foreign body.

#### SUMMARY AND CONCLUSIONS

A foreign body lodged in the external auditory canal may cause damage to the tympanic membrane and the tympanic cavity. The patient may not be aware of the presence of the foreign body. Early removal of foreign bodies is advised, especially when they are substances which cause necrosis of tissues. Great care is necessary to avoid injuring the tympanic membrane during manipulation of the foreign body. The use of general anesthesia is advisable during removal of lodged foreign bodies.



# LEMPERT ENDAURAL SUBCORTICAL MASTOIDOTYMPANECTOMY FOR THE CURE OF CHRONIC PERSISTENT SUPPURATIVE OTITIS MEDIA

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THE CHIEF complaint of almost every patient suffering from otitis media purulenta chronica without intracranial complications, for whom mastoidotympanectomy is indicated and advocated by his otologist, is, as a rule, the annoying discomfort of the persistence of his long-standing middle ear discharge, the arrest of which has resisted all available medicinal therapy

The average otologist, when suggesting the advisability of the patient's undergoing mastoidotympanectomy, is, however, reluctant to comfort the patient with the reasonable assurance that if he accepts the advice offered, a permanently dry middle ear will be his reward. The same otologist will nevertheless often volunteer unhesitatingly the unsolicited information that by submitting to this operation the possibility of intracranial extension of the presently existing infection will be avoided

Both the unwillingness of the otologist to reasonably assure the patient of a permanently dry middle ear and his volunteering the information that intracranial extension of the infection will thus be prevented are, as a rule, statements of facts which he has observed in his own experience of the mastoidotympanectomy without attempting to analyze and determine the *raisons d'être* which make such scientifically inconsistent facts possible

The prevention of intracranial extension of the infection is naturally governed by the same surgical factors in the performance of mastoidotympanectomy which govern the arrest of the suppurative discharge, namely, the complete exenteration of the foci of infection. It is therefore inconsistent for an otologist to give hope for the prevention of extension of the infection in the face of his lack of confidence regarding his ability to arrest the discharge

The right to suggest that the mastoidotympanectomy which he will perform will, as a rule, prevent intracranial extension of the infection could therefore be his only if he could also assure the patient of obtaining a permanently dry middle ear as a result thereof

A careful analysis of the natural clinical course of otitis media purulenta chronica would illustrate to him that the failure of intracranial extension to occur in the vast majority of instances despite the fact that

the discharge was not arrested by the operation need not necessarily be credited to the mastoidotympanectomy which he performed, since the incidence of such extension of otitis media purulenta chronica is naturally quite small even without surgical intervention

A critical self analysis of the way he performs a mastoidotympanectomy would however definitely clarify for him why he cannot reasonably promise a dry ear. He would soon be convinced that such a promise cannot, as a rule, be fulfilled unless all the foci responsible for the infection are completely exenterated

In other words, if he were to analyze the statements which he made, he would find that the conservatism of his refusal to promise the patient a dry ear is based on his uncertainty of succeeding in the removal of the foci of infection with mastoidotympanectomy as he performs it, while his extravagant promise to prevent the infection from spreading is based on the normally inherent odds against intracranial extension of the infection, which favor this promise despite the fact that he may perform the mastoidotympanectomy incompletely

In order for an otologist to place himself in the position of being able to give his patient the naturally expected reasonable assurance that with the mastoidotympanectomy which he intends to perform the middle ear purulency will cease to exist and to volunteer the information that the intracranial extension of the middle ear infection will also be prevented—prevention which can follow only if the middle ear purulency has been permanently arrested—he must (1) be confident that in performing the mastoidotympanectomy he will always explore all the pathologic processes responsible for the existing discharge and completely remove them and (2) choose a technic for performing the mastoidotympanectomy which is most conducive and most encouraging to such exploration and exenteration of the pathologic processes involved

Any one or more of the following pathologic involvements may be encountered during the performance of the mastoidotympanectomy

- 1 Chronic suppuration of cell structure of the mastoid process
- 2 Cholesteatoma within the antrum or extending from the antrum to any part of the mastoid process
- 3 Infected polypi and granulations within the antrum of the mastoid process
- 4 Necrosis of the bony plate of the dura in the region of the middle or the posterior fossa
- 5 Necrosis of the bony plate of the lateral sinus
- 6 Necrosis of retrofacial cells of the mastoid with chronic abscess in the retrofacial cell region
- 7 Chronic epidural abscess in the region of the middle fossa or of the posterior fossa
- 8 Chronic perisinus abscess in either the anterior or the posterior perisinus cell region
- 9 Chronic abscess in the region of the emissary vein
- 10 Chronic necrosis of the zygomatic cells
- 11 Necrosis of the perilabyrinthine cell structure

- 12 Necrosis of the mastoid portion of the fallopian canal with exposure of the facial nerve
- 13 Cholesteatomatous erosion with fistulization of the bony capsule of the external semicircular canal
- 14 Cholesteatomatous erosion with fistulization of the bony capsule of the superior semicircular canal
- 15 Cholesteatomatous erosion with fistulization of the bony capsule of the posterior semicircular canal
- 16 Cholesteatoma in the epitympanum
- 17 Polypi and granulations in the epitympanum
- 18 Necrosis of remnants of the ossicular chain
- 19 Cholesteatoma in the tympanum
- 20 Polypi and granulations in the tympanum
- 21 Necrosis of epitympanic and tympanic portions of the fallopian canal, with the facial nerve exposed and covered by granulation tissue
- 22 Thickened, infected mucoperiosteum lining the promontory of the cochlea and the rest of the tympanic cavity
- 23 Fistula in the cochlear promontory
- 24 Cholesteatoma, polypi and granulations in the hypotympanum -
- 25 Necrosis of the protective bony dome of the bulb of the jugular vein
- 26 Necrosis of perieustachian cells
- 27 Infected tensor tympani muscle
- 28 Necrosis of the tympanic pericarotid cells
- 29 Necrosis of the bony wall of the tympanic carotid canal
- 30 Chronic suppuration of the apical retrocarotid cells
- 31 Cholesteatoma and granulations surrounding and enveloping the stapedial crura in the oval window niche
- 32 Granulations and polypi filling the round window niche
- 33 Granulations and polypi in the region of the tympanic orifice of the eustachian tube

If a permanently dry middle ear is to be obtained as a result of a mastoidotomy, then any one or more of the aforementioned pathologic involvements, when present, must be explored and removed. The traditionally accepted and most commonly employed technic of mastoidotomy, known as the Schwartz postauricular radical mastoidectomy, is not conducive to, and does not encourage, the average otologist to either successfully explore, or completely eradicate surgically when explored, the varied and multiple pathologic processes which may be encountered. Only after a large experience of this technic can the especially skilled otologist cope successfully with the commonly encountered small sclerotic mastoid process and perform a complete mastoidotomy, and then not always without accident.

Judging by the incomplete manner in which the Schwartz postauricular radical mastoidectomy is being performed by the average otologist, one must conclude that the adjective "radical" appears to be an exaggeration. Considering the inadequacy with which this procedure is being performed in the majority of instances, one does not

wonder that the patient's hope of obtaining a permanently dry middle ear as a result of submitting to this surgical procedure is most often not fulfilled

The average otologist when performing the Schwartze radical mastoidectomy does not in the majority of instances remove completely the pathologic process responsible for the middle ear discharge. The inadequate performance of the Schwartze postauricular radical mastoidectomy is usually prompted by the surgeon's fear of injuring instrumentally one or more of the many vital anatomic structures which may be encountered blindly (1) when he attempts to reach and explore through the outer cortex of the mastoid process the deeply situated antrum for the purpose of becoming oriented with the temporal bone, (2) when he removes the posterior bony wall of the external auditory canal from without inward, directing the instrumentation toward the tympanic cavity, and (3) when he tries to explore and inspect the delicate vital anatomic structures within the tympanic cavity which are hidden from view by the pathologic contents.

Ever since the radical mastoidectomy was first described by Schwartze, young otologists have been traditionally warned of the inherently existing danger of injuring accidentally the lateral sinus, the dura of the middle and the posterior fossa, the posterior end of the external semicircular canal and the mastoid portion of the facial nerve when blindly searching for and exploring the antrum of the mastoid process through the outer cortex approach. Various means of attempting blindly to dodge these vital anatomic structures have therefore been taught. The danger of accidentally and blindly injuring the external semicircular canal and the tympanic portion of the facial nerve during the process of removing the posterior bony wall of the external auditory canal for the purpose of converting the antrum and the tympanic space into a continuous postoperative cavity has always been greatly stressed. Instruments called facial nerve protectors were devised for the purpose of blindly protecting the facial nerve from suffering such blind accidental injury. Otologists have been especially warned of the danger of injuring the facial nerve, dislocating the stapes and injuring the cochlear promontory in attempting to remove the pathologic contents and tissues from the tympanic cavity.

As a result of this generally accepted and practiced method of teaching how blindly to dodge the vital structures in the hope of indirectly saving them from accidental injury, there is developed in the average young otologist a fear complex which inhibits and prevents him from performing the Schwartze radical mastoidectomy adequately. Having been constantly trained to dodge the vital anatomic structures in order to avoid injuring them, when he has successfully opened the antrum of the mastoid process and removed the posterior bony wall of the external auditory canal and succeeded in dodging, often without even

visualizing, the vital structures involved, he usually calls it a day and quits. Having luckily avoided injuring any of the vital structures so far, he dares not tempt fate further and dodges the necessary exposure of the vital structures in the tympanum by leaving most of the pathologic processes within the tympanic cavity untouched, in the hope that nature will step in and finish what he had no courage to complete. However, nature only seldom obliges, and thus a permanently dry middle ear is too often not obtained as a result of the Schwartz postauricular radical mastoidectomy.

The adjective "radical" when applied to the Schwartz technic is therefore an exaggeration, for the way it is practiced by the average otologist makes the adjective "incomplete" more appropriate and more explanatory.

I should also like to call attention to the indisputable fact that the adjective "postauricular" as applied to the Schwartz radical mastoidectomy is a misnomer.

Mastoidotympanectomy cannot be performed through a postauricular incision alone. That incision must be supplemented with incisions made through the membranous lining of the posterior wall of the external auditory canal in order to create unobstructed, open and continuous postoperative accessibility of both the tympanic cavity and the mastoid process through the external auditory canal. The Schwartz technic is therefore in reality a combined postauricular and endaural technic and not just a postauricular technic.

However, it is a well established fact today that mastoidotympanectomy can be performed through endaural incisions alone without a supplementary postauricular incision. The postauricular incision is therefore not only unnecessary but also nonsurgical in principle since it involves a sacrifice of soft tissue greater than necessary for accomplishing the desired result.

Experience has taught me that in performing the mastoidotympanectomy the complete removal of the pathologic processes responsible for the persistent middle ear discharge without subjecting the vital anatomic structures to the danger of blind accidental injury can best be accomplished by observing the following three surgical principles:

- 1 The employment of endaural incisions only, for the surgical approach to the mastoid process and the tympanum instead of the combined postauricular and endaural incisions.
- 2 The abandonment of the dangerous search for the antrum of the mastoid process, which is not essential for the purpose of orientation.
- 3 The surgical exploration and exenteration of the pathologic process by instrumentation directed away from the visualized vital anatomic structures toward oneself instead of from oneself toward the unseen vital anatomic structures.

Instead of exploring and surgically treating the pathologic processes within the temporal bone through a pathway which requires blind dodging of vital anatomic structures to save them from injury, there is employed a pathway of approach which permits these vital structures to be visualized and thereafter utilized as guides toward the safe and successful exploration and surgical treatment of the lesions

Based on these three surgical principles I have developed and employed for many years the following technic

#### ENDAURAL SUBCORTICAL MASTOIDOTYMPANECTOMY

**STEP 1**—This procedure immediately exposes both the mastoid process and the tympanic portion of the temporal bone through endaural incisions only, instead of separately exposing first the mastoid process through a postauricular incision and secondarily exposing the tympanic space through endaural incisions. It is accomplished as follows (a) Four endaural incisions through skin and periosteum are made

*First Incision*—Beginning at the tympanic ring, an incision is carried outward through skin and periosteum along the junction of the superior and posterior walls of the external auditory canal into the suprameatal membranous triangle and up to its apex

*Second Incision*—Beginning at the tympanic ring, an incision is carried outward through skin and periosteum along the junction of the inferior and posterior walls of the external auditory canal up to the lower end of the anterior margin of the concha

*Third Incision*—The skin and periosteum lining the innermost tympanic margin of the posterior wall of the external auditory canal is incised to connect the innermost ends of the first and second incisions at the tympanic ring

*Fourth Incision*—An incision is made through the skin, subcutaneous tissue and periosteum of the outer membranous portion of the posterior wall of the external auditory canal along the entire cartilaginous anterior margin of the concha, beginning with the outer end of the second incision, until it meets the outer end of the first incision in the apex of the membranous suprameatal triangle (See fig 1)

(b) The skin flap created by the four just mentioned endaural incisions is removed with a periosteal elevator and conserved to be employed for skin-grafting the postoperative wound of the temporal bone (See fig 2)

(c) The auricle is mobilized by freeing the intact postauricular skin and periosteum from its attachment to the cortex of the outer part of the mastoid process and freeing the antauricular skin and periosteum in the region of the posterior root of the zygoma with the use of a periosteal elevator

(d) Self-retaining retractors are introduced into the membranous wound and held so that a complete exposure of the mastoid and tympanic portions of the temporal bone results (See fig 3)

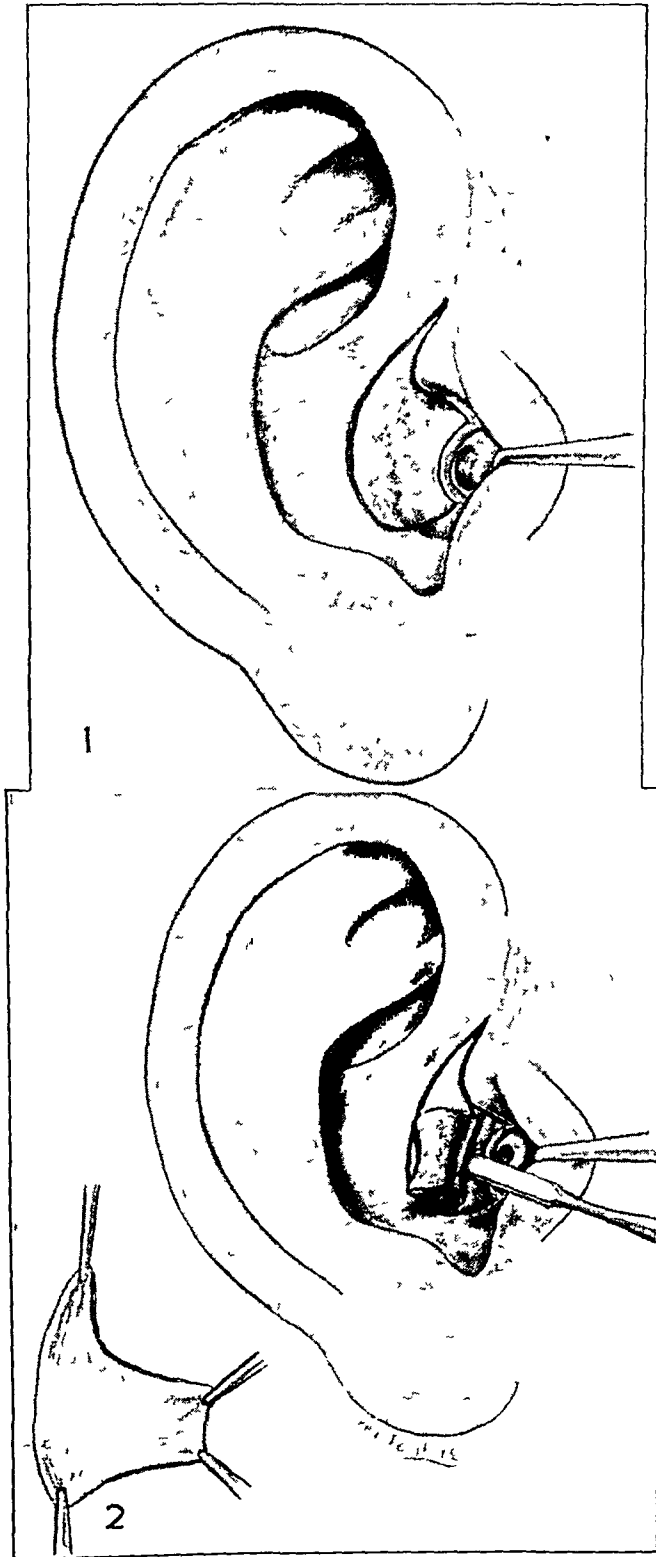


Fig 1—Four endaural incisions are made through skin and periosteum

Fig 2—A skin flap is removed and saved for skin-grafting of the postoperative bony cavity

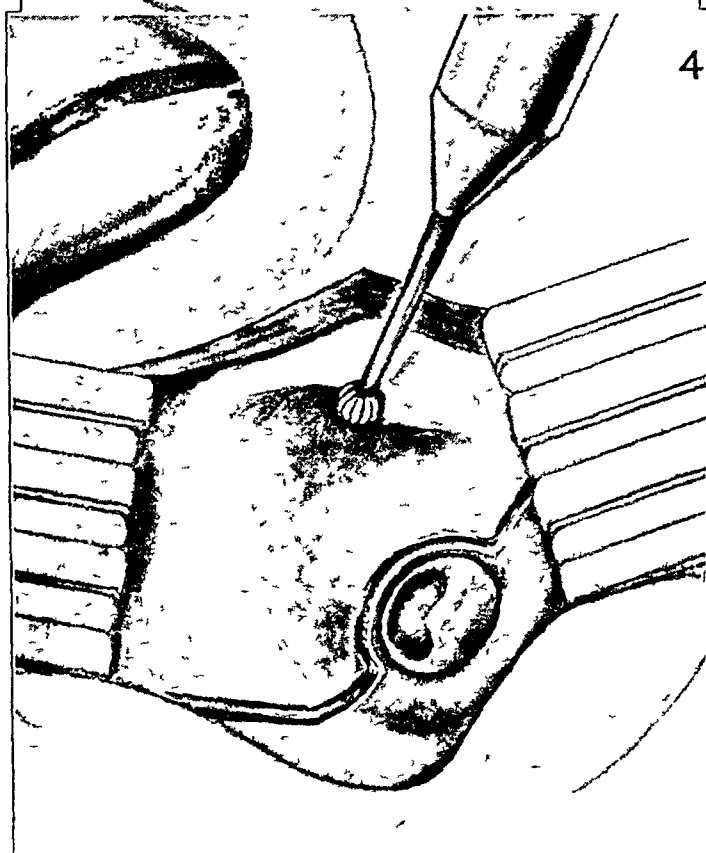
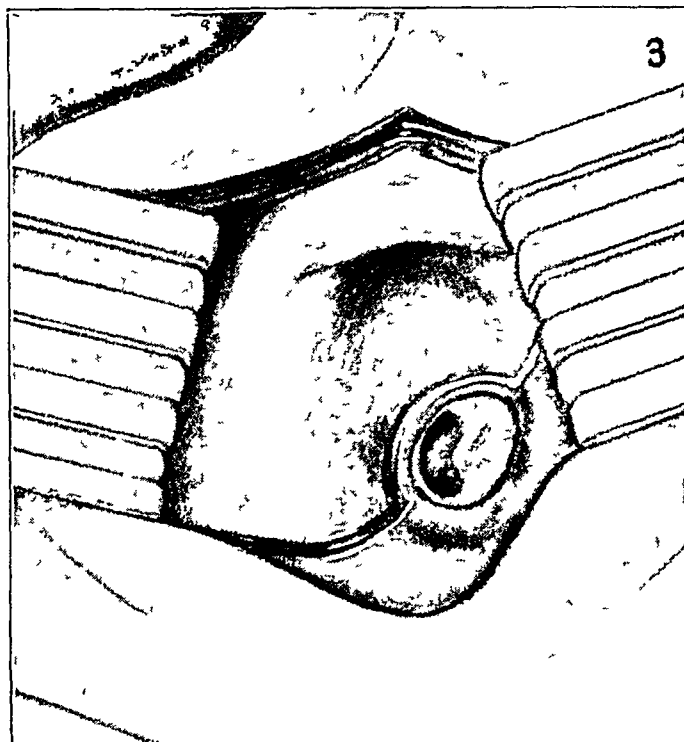


Fig 3—The cortex of the outer portion of the mastoid process, the spina Henle and the cortex of the entire anterior portion of the mastoid process can now be seen

Fig 4—With an electrically driven dental cutting burr, spina Henle is removed, and the external auditory canal is widened



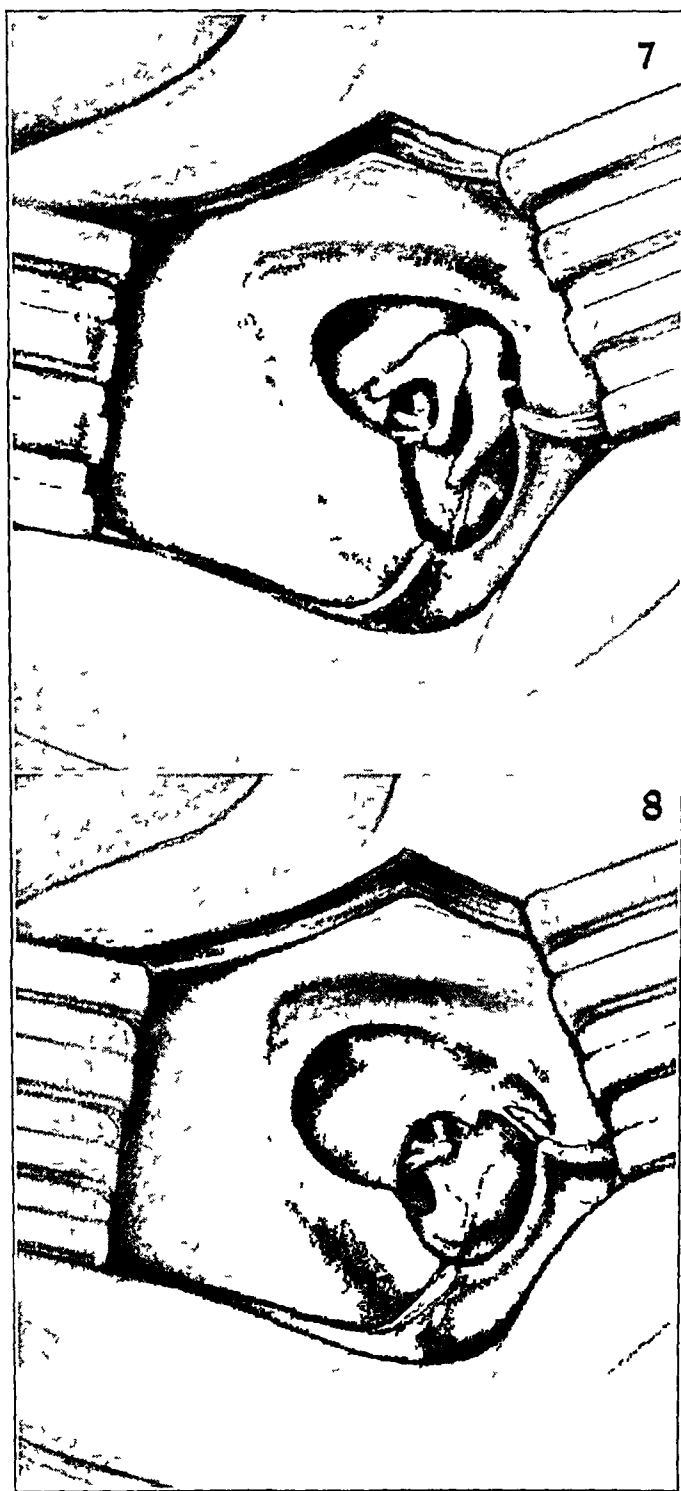


Fig 7—The cortex of the anterior part of the mastoid process has been further removed with the burr, working from within outward and exposing to view the incudostapedial joint and the external semicircular canal

Fig 8—The incus, the malleus and the remnant of tympanic membrane have been removed, exposing to view the canal of the facial nerve, the processus cochleariformis, the stapes in situ, the round window niche and the cochlear promontory

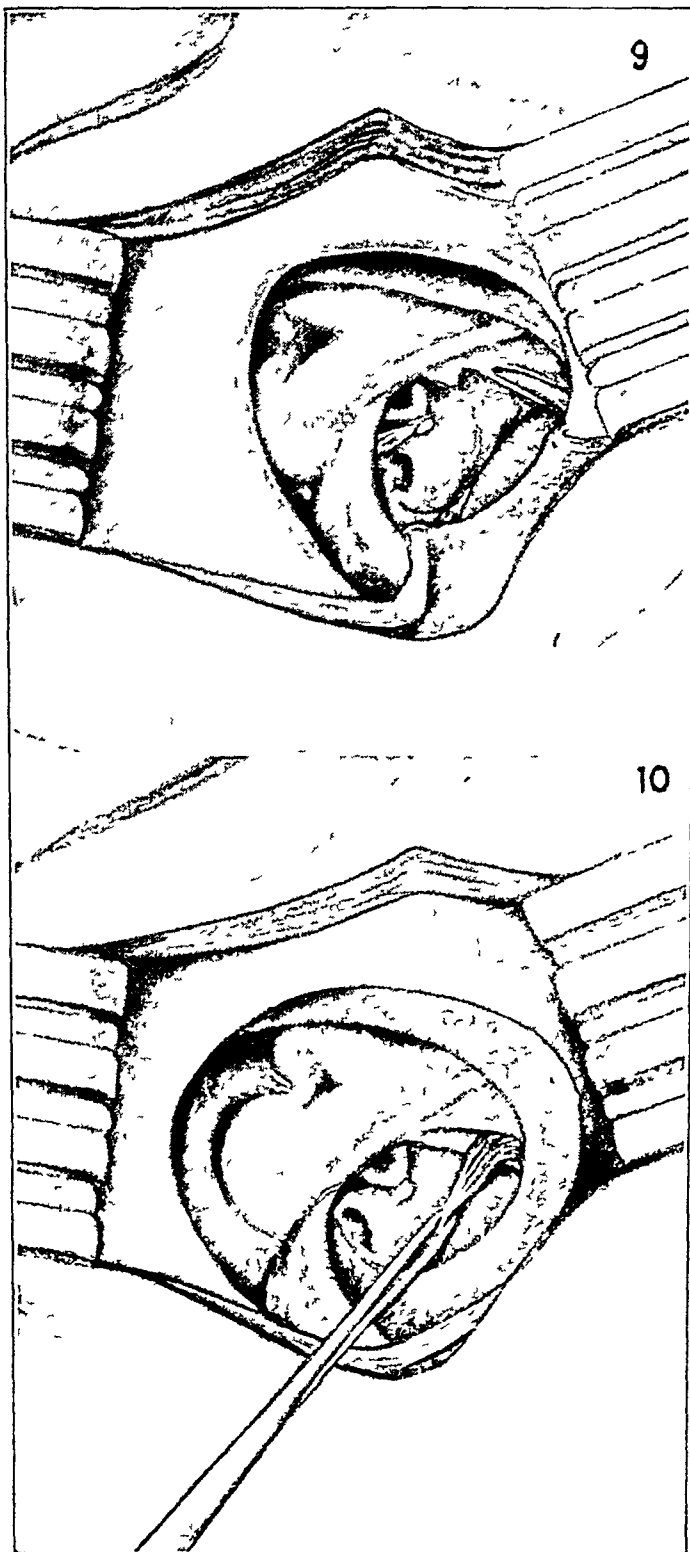


Fig 9—By removing the cortex of the anterior part of the mastoid bone still further in exenterating the mastoid cell structure, the three semicircular canals are exposed to view. The perieustachian cells and the pericarotid cells have been removed, exposing to view the semicanal with the infected tensor tympani muscle and the carotid canal.

Fig 10—The floor of the external auditory canal has been leveled to the floor of the hypotympanum. The diseased mucoperiosteum lining the tympanic cavity has been removed. The removal of the infected tensor tympani muscle from its semicanal is begun.

with the floor of the external auditory canal. The pathologic contents of the hypotympanum are thus exposed to view and rendered easily accessible to surgical treatment. (See figs 5, 6 and 7.)

STEP III—In this step all the vital anatomic structures normally present within the mastoid process and the tympanic space are safely exposed to view by removing all the pathologic processes which surround and involve them, through careful instrumentation directed away from the vital structures, with the aid of proper illumination and adequate magnification.

In order to obtain a permanently dry middle ear and to avoid the possibility of future intracranial extension of the infection of the middle ear, it is absolutely essential that all the existing pathologic contents and tissues within the mastoid process and tympanic spaces should be removed. The hope of accomplishing complete removal of the pathologic process rests on the thoroughness of the search for, and exploration of, the existing pathologic involvements.

Unless the mastoidotomy includes a complete exenteration of the cells of the mastoid process, including the perilabyrinthine cell structure, with exposure and surgical treatment, if necessary, of the entire inner bony table in the regions of the middle fossa, the posterior fossa, the lateral sinus, the basal vestibular labyrinthine portion of the petrous pyramid and the transmastoid course of the facial nerve, the result desired must remain within the realm of doubt. A thoroughly complete mastoidectomy must always be part of the mastoidotomy-tympanectomy. By the same token neither can the end result of a mastoidotomy-tympanectomy be anything but doubtful unless the entire inner bony table of the tympanum, epitympanum and hypotympanum is exposed to view and explored. In addition to removing granulations, polyps and cholesteatomas from the tympanic cavity it is also essential to remove any granulations that may be present in the region of the oval and round window niches. The perieustachian cells should be removed, and the pericarotid cells should be removed as well. The osseous tympanic portion of the eustachian tube should never be curetted, in order to avoid osteomyelitis resulting therefrom. The processus cochleariformis and the entire infected tensor tympani muscle should be removed from its semicanal. The diseased mucoperiosteum lining the inner bony walls of the tympanic space should be removed and the tympanic inner bony walls exposed to view. The cochlear promontory, the canal of the facial nerve, the epitympanic tegmen of the middle fossa and the hypotympanic bony dome of the bulb of the jugular vein and the bony canal of the carotid artery should be carefully inspected and any necrotic areas observed should be surgically treated. (See figs 8 to 11.)

STEP IV—Rapid and complete healing is promoted by skin-grafting the postoperative wound of the temporal bone which has been freed from all the pathologic material which surrounded and invested it. (See figs 12 and 13.)

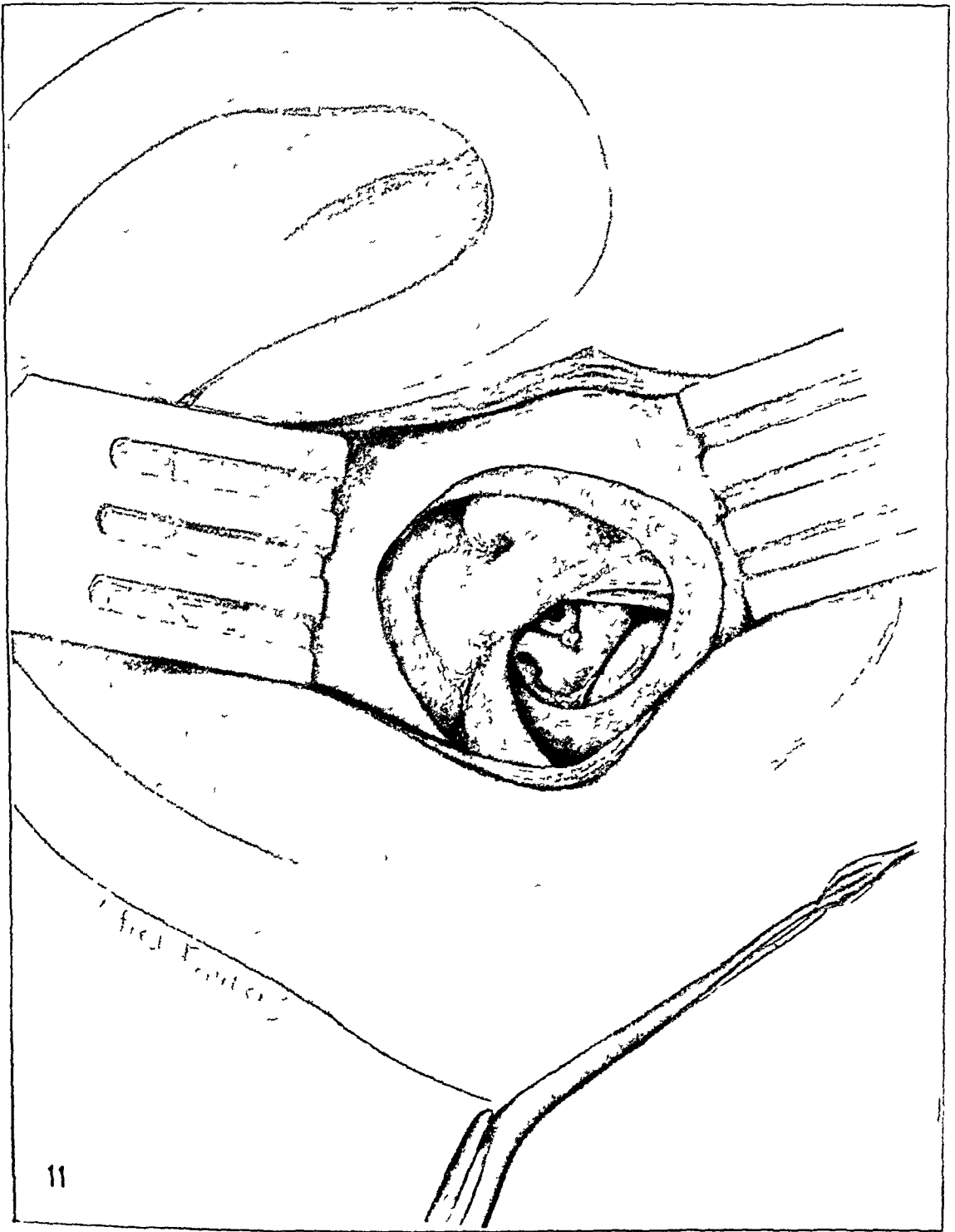


Fig 11—Cells of the mastoid process have been excised. The three semicircular canals have been defined. The floor of the external auditory canal has been leveled to the floor of the hypotympanum. The pericarotid and pericustachian cells have been removed. The infected tensor tympani muscle has been completely removed from its semicircular.

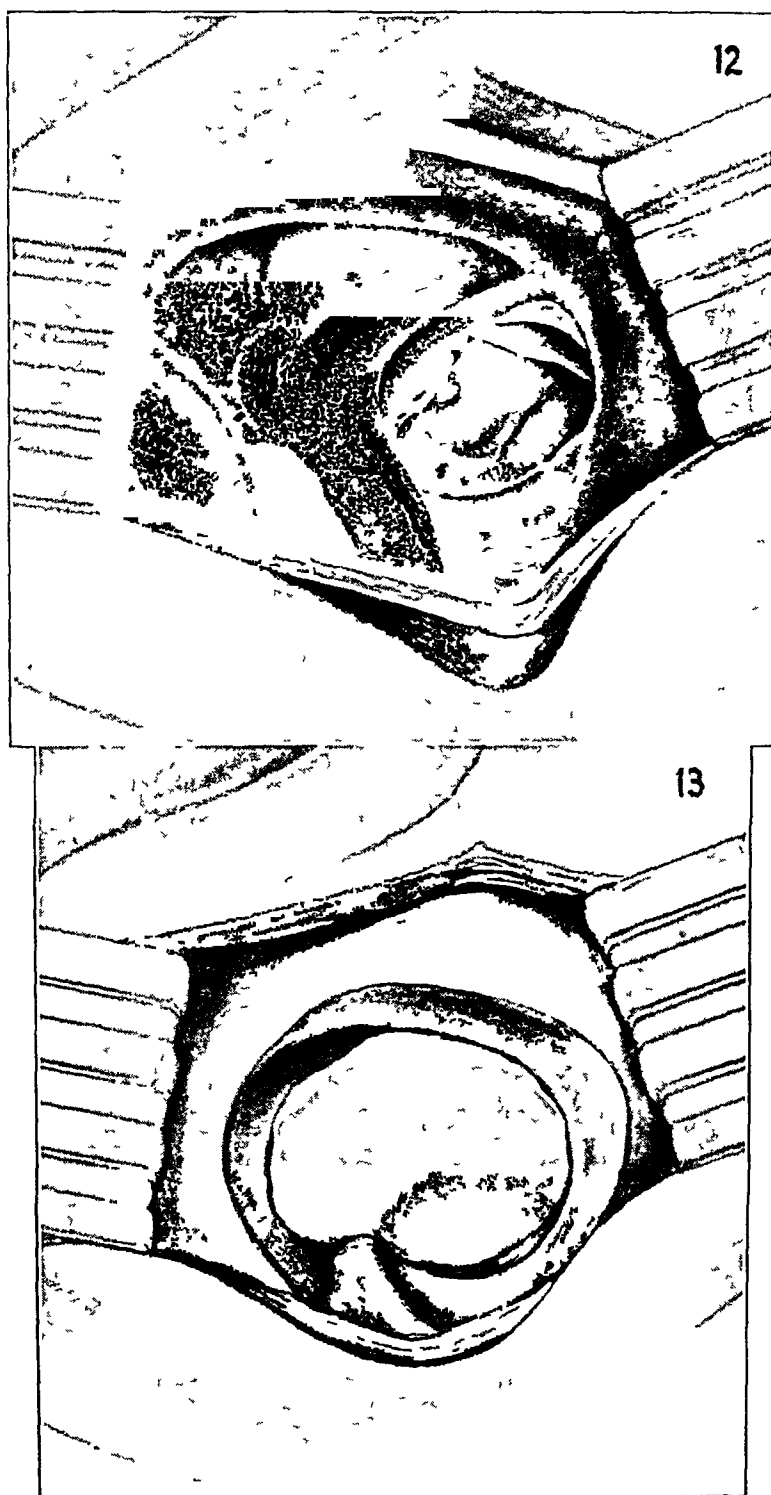


Fig 12—The cortex of the outer part of the mastoid process has been removed, exposing to view the completely exenterated mastoidotympanic wound

Fig 13—The postoperative mastoidotympanic cavity is skin grafted with the skin flap which was removed from the external auditory canal

The mastoidotympanic postoperative cavity is skin-grafted with split thickness skin grafts. When the cavity is not too large as it is usually when the mastoid process was small and sclerosed, the skin flap obtained as a result of the four endaural incisions and carefully trimmed to the desired thickness is more than sufficient to cover the entire postoperative cavity. The cavity is packed and the skin graft is held in position with  $\frac{1}{2}$  inch (1.27 cm) gauze strips dipped in sulfathiazole jelly. The packing is removed five days after operation. Sulfathiazole powder is insufflated into the cavity every other day thereafter. The patient leaves the hospital on the seventh postoperative day. The mastoidotympanic wound is completely epithelized and dry as a rule between four and five weeks after operation.

#### ADVANTAGES

1 By abandoning the blind search for the antrum of the mastoid process with instrumentation directed from without inward through the cortex of the outer part of the mastoid process and instead exploring the confines of the mastoid process by first removing the anterior cortex with instrumentation directed from within outward, blind accidental injury of the vital anatomic structures within the mastoid process can always be avoided.

2 By directing all one's instrumentation within the mastoid process and the epitympanum, tympanum and hypotympanum away from the vital anatomic structures toward oneself, all the pathologic processes encountered can be removed without danger of injuring these anatomic structures, provided proper illumination and adequate magnification are also employed. A permanently dry middle ear will, as a rule, be the reward of such thorough extirpation.

3 Since the postauricular incision has been avoided, the postoperative occurrence of a postauricular fistula is no longer possible.

4 The Lempert endaural subcortical mastoidotympanectomy technic, unlike the Schwartze postauricular radical mastoidectomy, is based on anatomic lines and sound surgical principles. Whereas, the successful employment of the Schwartze technic is reserved for the exceptionally skilful otologist who has learned through bitter and prolonged experience how to cope with all its inherent dangers, any well trained otologist of average skill though young in experience can successfully perform the endaural subcortical mastoidotympanectomy without being handicapped by the mental hazards which prevent him from performing the Schwartze radical mastoidectomy successfully.

By adopting the endaural subcortical technic, the otologist may reasonably assure the patient with otitis media purulenta chronica that on submitting to mastoidotympanectomy his desire of obtaining a permanently dry middle ear will, as a rule be fulfilled and may volunteer the information that with such a result intracranial extension of the infection will also be avoided.

# ROUND WINDOW MEMBRANE OF THE COCHLEA

Experiments Demonstrating Its Physical Responses

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ONE OF the fundamental difficulties in the understanding of hearing is the lack of knowledge of the physical characteristics of the aural structures

Improved knowledge of the physics of the cochlea not only would give a more direct understanding of the processes found in the inner ear but would give the physicist and the mathematician the necessary foundation for mathematical-physical interpretations. The mathematical treatises have been handicapped in the past because the mathematician did not possess the necessary knowledge of physical constants to formulate his initial equations. The most splendid mathematical solution of any problem is unsatisfactory if the formulation of the initial equation contained physical errors. Many times biomatematicians working on the ear were defeated in their endeavors because the magnitude of dampening, elasticity, tension and other fundamental physical qualities of the anatomic structures could not be determined with the available methods.

Experiments were devised to furnish experimental data on the physical properties of certain structures of the inner ear. This paper is confined to the subject of the round window membrane. The literature shows great confusion as to the function of the round window. The majority of students of hearing consider the membrane of the round window as the necessary compensating area for the vibrating fluid in the cochlea. However, there is still a considerable number of those who believe that the round window is the portal of entry for sound. The question was complicated still more by the fenestration operation. In the otosclerotic patient the entering of sound energy through the oval window is impossible. Therefore, the entering of the stimulus through the round window is more a possibility in the sclerotic than in the normal ear. The need for greater knowledge of the physics of the inner ear cannot be demonstrated better than by citing the surgical treatment of deafness as it was practiced for a number of years by Hughson and Crowe<sup>1</sup>. The rationale of this treatment was

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1 Hughson, W, and Crowe, S. Experimental Investigation of the Physiology of the Ear, *Acta oto-laryng* 18 291, 1933

the assumption that the normal tension of the normal round window membrane is too low. Therefore, Crowe and Hughson concluded that the normal physical condition of the round window does not represent the optimal condition for sound conduction. The next step was that of increasing the tension of the round window by surgical means. It has been doubted by other observers - that the basic assumption of Hughson was correct. The surgical treatment of the round window has been discontinued as far as I know. However, the basic question as to the normal and the optimal tension of the round window membrane has not been solved.

A search of the literature of the last fifty years revealed that no attempt has been made to measure the physical characteristics of the membrane of the round window. Extensive anatomic or histologic studies have not been reported either. For example, no measurements of such an elementary quantity as the thickness of the membrane were found in the literature.

For this reason a series of anatomic and histologic studies preceded the physiologic investigations. The size, the shape, the thickness, the texture, the weight and the specific gravity of the round window membrane were studied. The physiologic experiments were performed on fresh human cadaver specimens and on living rabbits.

Utilization of fresh human cadaver specimens for physiologic acoustical work has proved valuable. The fresh cadaver specimen lacks the normal tonus of the muscles of the middle ear. However, the elastic qualities of membranes and ligaments are unchanged, according to experimental evidence. Frank<sup>3</sup> has measured the volume elasticity coefficient of the tympanic membrane and proved that the elastic qualities of that membrane are the same in a living person and in the fresh specimen. Von Békésy<sup>4</sup> recorded the natural frequencies of the living normal ear drum and compared them with the resonance frequency of the ear of the cadaver. He found that both the natural frequency and the dampening are identical. He concluded, therefore, that "the observations made on the fresh cadaver specimen have general application provided certain precautionary measures are taken."

The membrane of the round window is rather hidden. While the niche of the round window has been seen by every otologist innumerable times, a gross view of the entire membrane requires considerable

2 Culler, E., Finch, G., and Girden, E. Function of the Round Window in Hearing, *Am J Physiol* **111** 416, 1935. Milstein, T. N. Zur Technik der Einmauerung des runden Fensters, *Acta oto-laryng* **25** 387, 1937.

3 Frank, O. Die Leitung des Schalles im Ohr, *Sitzungsb d Gesellsch f Morphol u Physiol* **24** 34, 1923.

4 von Békésy, G. Ueber die mechanisch-akustischen Vorgänge beim Hören, *Acta oto-laryng* **27** 281, 1939.



careful dissecting (fig 1) Most otologists therefore visualize this membrane only as a histologic entity seen on cross sections of their specimens of the temporal bone The histologic examination has the disadvantage, of course, that the tissue has been subjected to extensive chemical changes inherent in the common histologic technic Figure 1 shows the round window membrane of a temporal bone of a fresh



Fig 1—The round window membrane of the cochlea is a thin membranous structure occluding the bony aperture between the scala tympani and the middle ear cavity The area of the membrane is about 2 sq mm The membrane is not strictly round

human cadaver It is evident from this picture that the membrane is not exactly round The name "triangular membrane" would be appropriate The cochlear window has therefore been called foramen triquetrum in the literature The physiologic role of the round window

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5 Denker, A, and Kahler, O Handbuch der Hals-Nasen-Ohrenheilkunde, Berlin, Julius Springer 1926, vol 6, p 459

is difficult to study because of the physical arrangement. The membrane represents a boundary between a fluid system and an air space. The physics of the fluid system in the inner ear is inadequately understood. All physical experiments, in which the membrane might be studied *in situ* would contain variable and unknown factors of the membrane as well as others of the cochlea. For the purpose of physical analysis it seemed essential, therefore, to study the membrane separately, with air on each side of the membrane. This is technically possible. The name 'isolated round window membrane' will be used for this preparation (fig. 2).

#### SETUP FOR EXPERIMENTS ON THE ISOLATED ROUND WINDOW MEMBRANE

Fresh human cadaver ears were used. The middle ear was opened and the round window exposed. With a dental drill, the round window region was care-

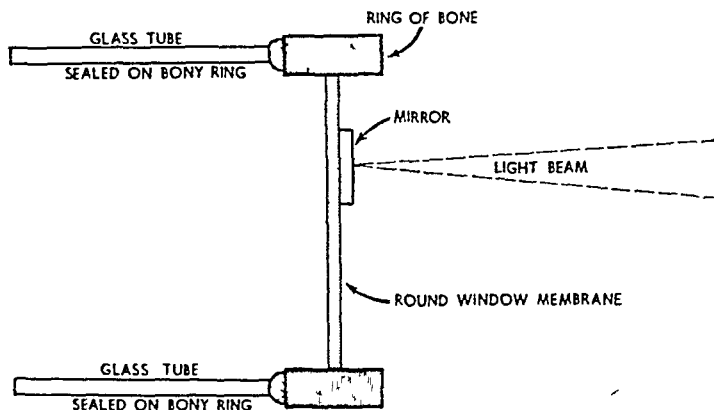


Fig. 2—Scheme illustrating the isolated round window specimen. The round window membrane and the adjacent bone tissue are removed from the cochlea of a fresh human cadaver ear. A glass tube is attached to the bony ring and sealed tightly. A small mirror is attached to the opposite side of the round window membrane. Sound pressures as well as changes of static pressure are conducted into the glass tube.

fully separated from its surrounding. A ring of bone several millimeters thick, containing the round window membrane, was removed. A glass tube of proper diameter was sealed over the ring. By this procedure a specimen was obtained which consisted of a canal (glass tube), the end of which was closed by the membrane of the round window. A syringe was used to produce static pressure changes in the glass tube. The pressures were measured by a water manometer. On the other side of the round window membrane a small mirror was attached. The location of the mirror was about halfway between the center and the edge of the membrane.<sup>6</sup> The mirror was 0.030 inch long and 0.015 inch wide (0.75 by 0.375 mm). The rotatory movements of the mirror could be recorded by the deviation of a light beam (fig. 2). In addition to static pressure changes, acoustic stimuli could be sent into this system. The response of the membrane to tones was measured.

<sup>6</sup> The optimal distance ( $d$ ) from the center of the membrane is  $d = \frac{R}{\sqrt{3}}$

RESPONSE OF THE ISOLATED ROUND WINDOW MEMBRANE TO  
STATIC PRESSURE CHANGES AND A TONAL FREQUENCY

Figure 3 shows the response of the round window membrane to changes of static pressure. On comparing the excursions due to

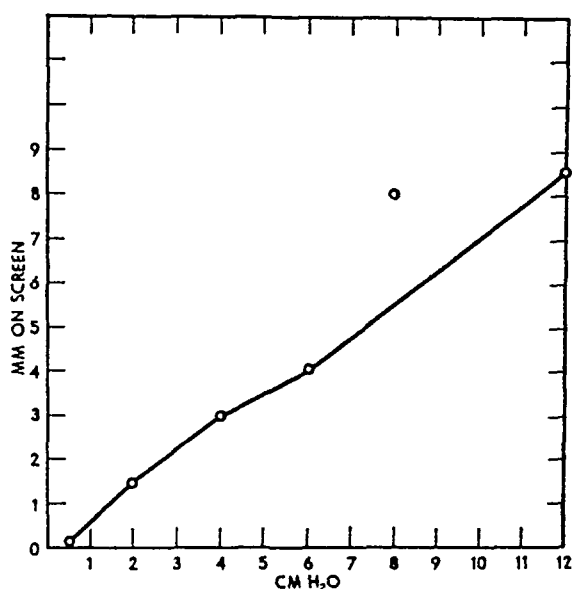


Fig 3—The response of the isolated human round window membrane to changes of static pressure. A bulging of the membrane results in a rotation of the mirror attached to the membrane. The resulting deflection of a light beam is measured on a screen. In each experiment the distance between specimen and screen was determined. By simple trigonometry it was possible to calculate the rotation of the mirror from the deflection of the light beam measured on the screen. In turn the amplitude of the excursion of the membrane could be estimated in regard to its order of magnitude if the position of the mirror on the membrane was known.

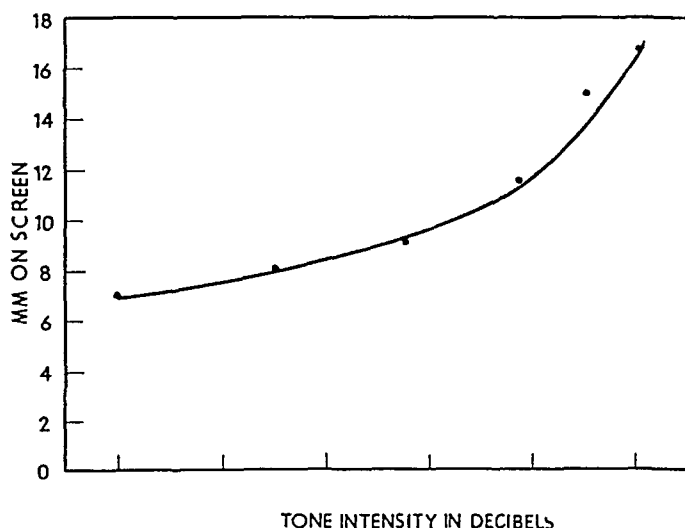


Fig 4—Acoustic vibrations of the isolated round window membrane. The experimental setup is described in figure 2. The abscissa is the intensity of the tone  $C^2$ . The ordinate designates millimeters of deflection on the screen.

positive, or plus, pressures with those due to negative, or minus, phases it was seen that for the range of pressure changes which were used and with the sensitivity of the experimental setup the two phases produce equal amplitudes. This finding is important, for similar experiments done on the round window membrane *in situ* show distinct asymmetry of amplitudes. By using the isolated round window membrane it is possible to show that this asymmetry is not due to the physical characteristics of the fenestra rotunda but is due most likely to those of the middle ear apparatus.

When a tone was conducted into the specimen, a response curve such as that seen in figure 4 was obtained.

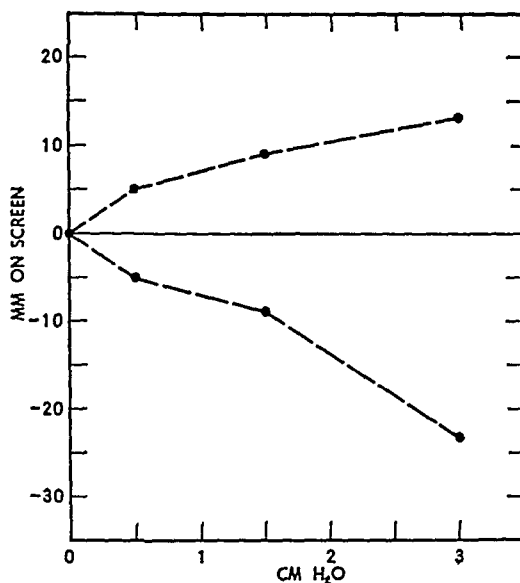


Fig 5—The experimental setup was as follows. A fresh human cadaver ear with the round window membrane *in situ*, a small mirror attached to the round window membrane, changes of static pressure produced in the canal of the outer ear. Positive amplitudes are recorded above the zero line, negative amplitudes, below the zero line. Note the asymmetry of the response curves. Negative phases of pressure in the external auditory canal produce greater amplitudes than positive phases.

#### RESPONSE OF THE ROUND WINDOW MEMBRANE *IN SITU* TO STATIC PRESSURES AND ACOUSTIC STIMULI

The next step was the determination of the fenestral response to stimuli applied in the outer auditory meatus. Cadaver specimens were prepared in such a way that the whole outer and middle ear were intact but the round window niche was exposed from below. A mirror was attached to the round window membrane. Static pressure changes or tones, respectively, were conducted by means of a tube into the canal of the outer ear. The curve for static pressures is seen in figure 5.

It is evident that a negative pressure in the external auditory canal produces a greater amplitude of movement of the round window than an equally strong positive pressure. The curve shows that the light beam was deflected 23 mm on the screen by a negative pressure of 3 cm of water. On the other hand, a positive pressure of 3 cm of water produced a deflection of only 13 mm on the screen.

It is easy to calculate the degree to which the mirror rotates on the membrane from the measured values of light deflection. By simple trigonometry it is evident that the angle of rotation of the mirror due to a minus pressure in the outer canal of the ear was  $0^{\circ} 39'$  while the corresponding plus pressure produced a rotation of  $0^{\circ} 22'$ . It is possible to estimate the order of magnitude of the amplitude of the center of the round window membrane. If one assumes a radius of 0.6 mm for the membrane, one obtains<sup>7</sup> the following amplitudes:

Minus pressure of 3 cm of water in external canal 0.00678 mm of amplitude  
 Plus pressure of 3 cm of water in external canal 0.0029 mm of amplitude

Acoustic amplitudes can be measured similarly. The proportion of plus to minus amplitude is seen in figure 6. For small values no attempt was made to differentiate between plus and minus response. The three columns on the left in figure 6 are therefore not subdivided. Larger amplitudes due to greater tonal intensities in the external auditory canal were easily subdivided into the larger negative and the smaller positive phase. The proportion between the two is about 7:5.

The asymmetry of the ossicular chain is similar to that observed on the round window membrane. Values for positive and negative movements of the tympanic membrane or hammer vibrations show a similar ratio. As seen in the experiments on the isolated round window, the asymmetry is not due to the physical characteristics of the membrane. It is to be assumed, therefore, that the asymmetry observed in the round window membrane is due to the physical properties of the middle ear. This is experimental evidence that within this range of stimuli, at least, the cochlea is stimulated normally by an asymmetric signal. This fact could be used for an explanation of the fact that bioelectrical phenomena of the inner ear show a greater response to the negative phase of the pressure exerted in the outer auditory canal.

The optical recordings of the movements of the round window membrane were made by using one of the smallest and lightest mirrors.

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<sup>7</sup> The following formula was used in this calculation:

$$Y = R \times \sin \alpha$$

Where

$Y$  = amplitude

$R$  = radius of membrane

$\alpha$  = angle of rotation

that could be obtained through commercial channels. Their weight is about 10 mg.<sup>8</sup> When one of these mirrors is attached to a membrane, a new mass and stiffness factor is introduced. It is difficult to compute mathematically whether the change is significant or whether it may be neglected.

A second experimental observation different in method may be used to decide this important question. It is more practical than extensive mathematical calculations. It consists in the direct recording of amplitudes by means of moving picture film.

With the moving picture recording, furthermore, no interference with the delicate anatomic structures is necessary. As described in a previous publication,<sup>9</sup> moving picture films have been evaluated quantitatively.

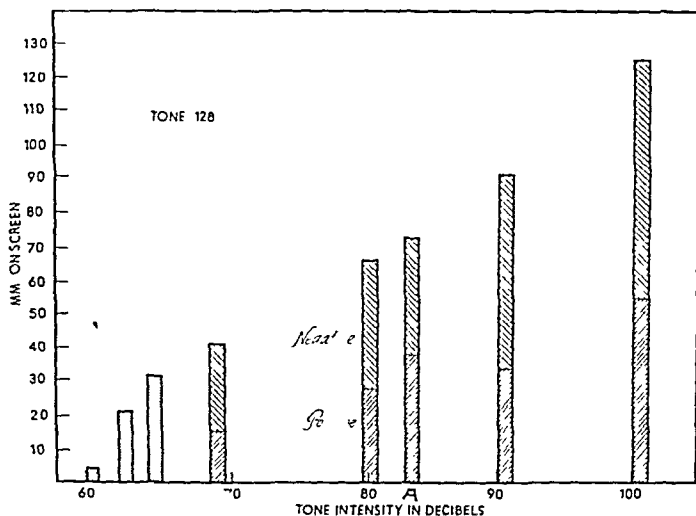


Fig. 6—Demonstration of the asymmetric response of the round window membrane of the cochlea (fresh human temporal bone used). The columns represent the response of the round window membrane to the tone of 128 double vibrations per second at various intensities. The lower part of the column (stripes running from right to left) represents the response to positive acoustic pressure in the outer auditory canal, the upper part (stripes running from left to right), the response to the negative phase of the tonal frequency. The amplitude of the vibration of the round window membrane is greater for the negative phase. The differences represented by the three columns on the left were too small for subdividing between plus and minus phase. At A the response of the isolated round window membrane is given, plus and minus amplitude are about equal. Note the linear response of the round window membrane to the sound is demonstrated by the height of the column. An imaginary line pulled through the left upper corner of the columns is fairly straight.

Well defined light points on the round window membrane, moving during acoustic stimulation (stroboscopic illumination), were used

<sup>8</sup> The information concerning weight was obtained from the General Electric Company by special communication.

<sup>9</sup> Kobrak, H. G. New Method of Scientific Investigation of Inner Ear, *Laryngoscope* 57:247, 1947.

A central light point is followed on the screen, and its amplitude on the screen is measured. By simple trigonometry, the real amplitude of the vibrating part is defined as

$$A = \frac{S \times \sqrt{2}}{C}$$

Where

$A$  = the real amplitude of the point of the membrane

$S$  = the optically enlarged amplitude as projected on the screen,

$C$  = the optical magnification factor (observation of membrane under an angle of 45 degrees)

The experiments demonstrated in figures 3 to 6 and those of the moving picture are not identical. Since the sensitivity of the moving picture recording is not as great, larger stimuli were used. Naturally, the resulting amplitudes are larger. The comparison, however, does show that the order of magnitude obtained by the one method is in agreement with that obtained by the other. The amplitude of the round window was found between 0.032 mm in one instance and 0.077 mm under strongest stimulation. This corresponds to a static pressure (determined by extrapolation) of about 50 cm of water for the strongest stimulus.

#### FENESTRAL SOUND CONDUCTION

The question whether sound is conducted directly through the round window has been debated for many decades, perhaps even for centuries. Schelhammer<sup>10</sup> discussed it in a book published in 1684. A number of authors<sup>11</sup> have stated their opinion that the cochlea receives its acoustic stimuli through the membrane of the round window. A larger number of investigators, however, consider the round window only as a compensatory opening for the vibrating fluid column of the inner ear.<sup>12</sup>

10 Schelhammer, G. C. *De auditu liber unus, quo plerorumque omnium doctorum sententiae examinantur, et auditus ratio, nova methodo, ex ipsius naturae legibus, explicatur*, Lugd. Bat., P. de Graaf, 1684.

11 Sappolini, cited by Politzer, A. *Geschichte der Ohrenheilkunde*, Stuttgart Ferdinand Enke, 1913, vol. 2, p. 48. Lucae, A. *Beiträge zur Lehre von den Schallempfindungen*, *Arch. f. Ohrenh.* **79** 246, 1909. Secchi, G. *La fenestra rotunda*, *Arch. ital. di otol.* **12** 49, 1901. Beyer, H. *Studien über den sogenannten Schalleitungs-apparat bei den Wirbeltieren und Betrachtungen über die Funktion des Schnecken Fensters*, *Arch. f. Ohrenh.* **77** 79, 1908. Zimmermann, G. *Zur Physik und Physiologie der Schallbewegung*, *Arch. f. d. ges. Physiol.* **144** 7, 1912.

12 Bezold, F. *Experimentelle Untersuchungen über den Schalleitungs-apparat des Ohres*, *Arch. f. Ohrenh.* **77** 19, 1908. Buck, A. *Untersuchungen über den Mechanismus der Gehörknöchelchen*, *Arch. f. Augen- u. Ohrenh.* **1** 121,

Observations of von Békésy<sup>13</sup> show that a person without tympanic membrane or ossicles hears the acoustic stimulus in opposite phase as compared with a normal observer. This difference of phase is understandable because ossicular conduction delivers the tone to the oval window and the scala vestibuli, while round window conduction delivers it to the scala tympani. The basilar membrane must vibrate in opposite phase according to the pathway of conduction by which the sound entered the cochlea.

The development of methods permitting responses of the ear to be measured objectively offers a new answer to the old problem. The experimental setup used in this study was as follows:

A fresh human cadaver ear was opened from below and the round window niche exposed. A glass tube was placed in the niche and fastened and sealed with plaster of paris. A second tube was inserted in the canal of the outer ear.

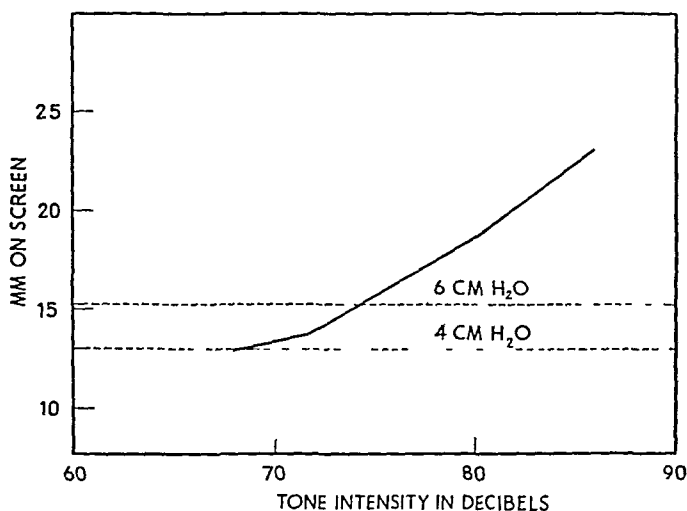


Fig 7—Fenestral sound conduction. A fresh human temporal bone was used. The round window niche was exposed from below and a glass tube inserted and sealed in the niche. The cochlea was stimulated by "reversed sound conduction", i.e., sound entered through the round window membrane. Compensatory movements of the stapes and the ossicular chain are measured by the recording of the vibrations of the incus. The abscissa is the intensity of the tone, the ordinate is the rotation of the incus expressed in millimeters measured on the screen. The two broken lines represent changes of static pressure applied through the round window membrane, with the corresponding rotation of the incus.

1870 Burnett, C. H. Untersuchungen über den Mechanismus der Gehörknöchelchen und der Membran des runden Fensters, *ibid* 2 64, 1872 Chilow, K. L. Zur Frage über die Ausgleichung des Labyrinthdruckes, *Ztschr f Hals-, Nasen- u Ohrenh* 5 404, 1923 Weber-Liel. Der Aquaeductus cochleae, *Monatschr f Ohrenh* 13 33, 1876 Huizinga, E. Die Tulliosche Reaktion im Zusammenhang mit der Funktion des Mittelohrapparates, *Arch f Ohren-, Nasen- u Kehlkopfh* 145 447, 1938

13 Békésy, G. Zur Physik des Mittelohres und über das Hören bei fehlerhaftem Trommelfell, *Akust Ztschr* 1 13-23, 1936



and fastened. The tegmen tympani was removed partly and a small mirror placed on the body of the incus. The vibrations of the incus were recorded optically. Figure 7 shows a curve of fenestral sound conduction. It was also possible to conduct tones either through the outer ear or through the round window niche. A direct comparison of the degrees of effectiveness of the two modes of sound conduction was thus possible.

The tubes conducting to the outer ear and to the round window niche were of equal length, equal diameter and equal material. With this arrangement, a certain tone was conducted through the outer ear and the amplitude of the vibration of the incus measured. By a turn of the switch the same tone was then conducted through the round window membrane and again the vibration of the incus was measured. In the former case one has the conventional ossicular sound

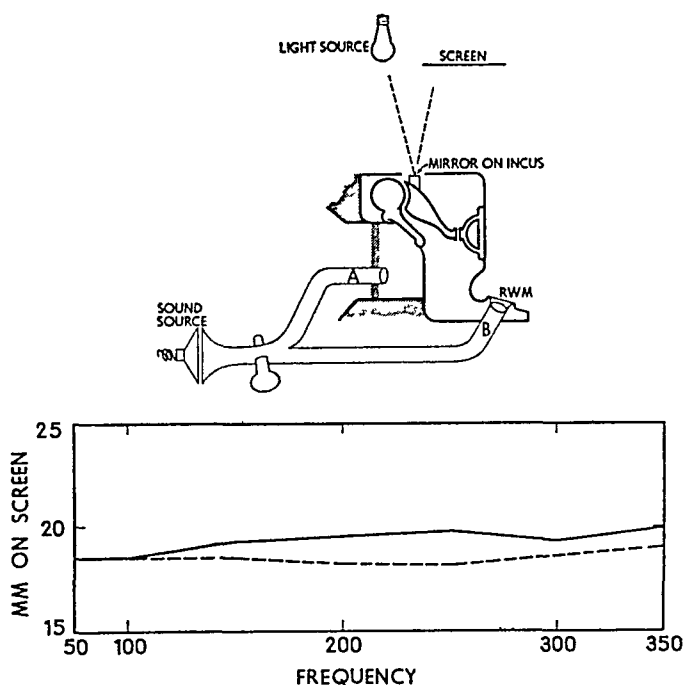


Fig 8—Comparison between meatal and fenestral sound conduction. Sound can be directed either through tube *A* into the outer auditory canal or through *B* directly against the round window membrane (*RWM*). The vibrations of the incus in response to meatal and in response to fenestral sound conduction were measured. The solid line represents amplitude of vibration due to meatal conduction, the broken line, that due to fenestral conduction. The two amplitudes are practically equal.

conduction. In the latter case the sound conduction is reversed, one deals with fenestral sound conduction.

The experimental results were rather definite (fig 8). The vibrations of the incus are about equal in ossicular and fenestral conduction. The difference in phase was obvious in optical recordings. It was possible to use the same experimental setup on the living animal. Sound was conducted by tube into the round window niche of a rabbit. The tensor reflex of the opposite ear was used as indicator of cochlear

function There was a good tensor reflex for sounds conducted into the round window niche All these experiments were carried out with the ossicular chain intact

#### SUMMARY

The round window membrane is a part of the sound-conducting system of the ear which has not been investigated extensively in the past

For analysis of physical properties, the membrane was removed from the cochlea (stretched in a bony ring) and subjected to static and dynamic tests This specimen was termed the "isolated round window specimen" Elasticity curves were obtained for static pressures and acoustic stimuli

The behavior of the round window membrane *in situ* constitutes a complex physical problem that of a membrane with fluid on one side and an air-containing cavity of barometric or near barometric pressure on the other side The membrane is coupled to the ear drum and ossicular chain and shows some of their physical characteristics—for example, the asymmetry Static and acoustic curves of the membrane *in situ* are demonstrated

A comparison of the amplitudes of the stapes and the round window membrane shows that the round window membrane executes larger excursions than the stapes Between the tympanic membrane and the stapes the amplitude of vibration diminishes, but it is increased again between the oval and the round window

For the frequency range tested, the inward movement of the round window membrane is greater than the outward movement This asymmetry is not maintained in the isolated round window specimen

Experimental evidence is brought forward which shows the response of the cochlea to fenestral sound conduction (sound entering the cochlea through the round window membrane) A quantitative comparison between meatal and fenestral sound conduction is given

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## EFFECTS OF ALLERGY ON THE ETHMOID SINUSES

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**I**N ALLERGY of the upper respiratory tract the soft tissue of the turbinate body is the primary shock organ. The ethmoid air cells and the maxillary sinuses are the first of the pneumatic cells of the skull to participate in allergic response because they are the air spaces most intimately related to the inferior and the middle turbinate bodies. The frontal sinuses tend to become involved later, and to a lesser degree, because of their less intimate relation to the turbinate bodies. Allergic changes in the soft tissue of the sphenoid sinuses are a comparative rarity because the orifices of these air spaces are still more remote.

The order and degree of allergic involvement of the sinuses can be gauged to some extent by examination of the paranasal sinuses of patients with bronchial asthma<sup>1</sup>. A group of these patients showed a high incidence of sinus disease in both a roentgenographic study (80.5 per cent) and a clinical study (67 per cent). In both examinations, mucosal abnormality was most frequent in the maxillary sinuses and appeared next, in order of decreasing frequency, in the ethmoid, frontal and sphenoid sinuses. (Whether the maxillary sinuses or the ethmoid air cells are first involved cannot be determined with absolute certainty because the early phase of allergic change in mucous membrane is more difficult to detect in the ethmoid cells than in the maxillary sinuses.)

There is little evidence to support the concept that allergic changes commonly occur in the paranasal sinuses prior to allergic changes in the turbinate bodies. On the other hand, it has become obvious that, once allergic alterations have taken place within the sinuses, these alterations may progress until an irreversible change has taken place in the tissue, which is no longer appreciably affected by abnormalities in the turbinate bodies<sup>2</sup>.

The primary allergic response in the upper respiratory tract usually appears in the tissue of the turbinate body and may be initiated by direct contact with an allergen which has gained entrance to the nasal passages or by the more indirect contact with blood-borne antigens absorbed from the gastrointestinal tract. In a sensitized person, absorption of

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<sup>1</sup> Kern, R. A., and Schenck, H. P. The Relative Efficiency of the Clinical and Roentgenologic Methods for Sinus Disease Diagnosis, *Am J M Sc* **178** 168 (Aug.) 1929

food or drugs in the gastrointestinal tract may initiate a very positive allergic response in the tissue of the turbinate body, but the role of blood-borne allergens is apt to be overshadowed by the more frequent effects of air-borne allergens. In an occasional patient a characteristic curious, granular, pale stippling of the posterior portion of the middle part of the turbinate body is the first evidence in the upper respiratory tract of food sensitization.<sup>2</sup>

The allergic changes in the turbinate bodies consist primarily of thickening and hyperplasia of the epithelium, edema of the basement membrane and edema and eosinophilic infiltration of the stroma. Actually, all these alterations are secondary to certain vascular phenomena precipitated when a specific allergen comes in contact with sensitized tissue. At least a portion of the mechanism thus brought into play was demonstrated in observations on the living tissues of animals, made under the high powers of the microscope.<sup>3</sup> The injection of horse serum, or of red blood corpuscles from fowl, into a rabbit sensitized to either antigen has the following effects: (1) the arterioles contract, blocking the circulation, (2) the consistency of the endothelium changes, so that the leukocytes adhere to the walls of the capillaries and venules in large numbers and emigrate into the surrounding tissue, (3) a change occurs in the leukocytes, so that they become cohesive, frequently occluding the venules and capillaries and sometimes forming leukocytic emboli, (4) no contraction of the blood capillaries or the small

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2 An exception to the usual train of events has been described by Proetz (Sudden Allergic Reactions in the Maxillary Sinuses, *J Allergy* **1** 324 [May] 1930), who observed sudden pronounced increase in the thickness of the mucosa of the maxillary sinus during an asthmatic attack, while a patient was undergoing roentgenologic studies and iodized oil U S P was present in the sinus. He suggested that the trauma incident to the introduction of contrast mediums might play a role in such a reaction. Similar bizarre allergic reactions may occur elsewhere in the respiratory tract. For example, a 50 year old physician, while inoculating rats during an experimental investigation, suddenly became hoarse, then aphonic and finally dyspneic. When examination was made ten minutes later, the obstructive dyspnea was so extreme that preparations were made for tracheotomy. The right vocal cord was pallid, edematous and in contact with the left false vocal cord. Forceful displacement of the right cord to the right revealed the left vocal cord to be essentially normal. Subcutaneous administration of a solution of epinephrine was followed within ten minutes by subsidence of the edema of the right vocal cord. Subsequent cutaneous tests demonstrated that he had a violent reaction to rat hair.

3 Abell, R. G., and Schenck, H. P. Microscopic Observations on the Behavior of Living Blood Vessels of the Rabbit During the Reaction of Anaphylaxis, *J Immunol* **34** 195 (March) 1938, The Behavior of Living Blood Vessels of the Rabbit During the Reaction of Anaphylaxis, *Anat Rec* **70** 1 (March) 1938. Schenck, H. P., and Abell, R. G. The Anaphylaxis Reaction. Tissue Changes as Observed in Living Tissue in the Rabbit, *Tr Am Larvng A* **60** 210, 1938.

venules occurs, and (5) the blood vessels do not become occluded by any specific precipitates

The gross changes in the nasal mucosa in allergy are probably also secondary to the vascular changes outlined in the preceding paragraph. The intimate relation between the vascular structures of the turbinate body and those of the ethmoid cells and the maxillary sinuses renders involvement of these sinuses almost inevitable if the allergic stimulus is of appreciable duration.

The thinner the lining membrane of a sinus, the more responsive it is to allergic stimuli and the more readily it partakes of the turbinal activity. The mucous membrane of the ethmoid air cells is thinner than that of the other sinuses, but in all other respects, including the presence of glands, it resembles the mucosa of the upper respiratory tract. The air-containing cells vary greatly in number and size, but they are separated from each other by their bony walls, and every space communicates with the nasal fossa, either directly, through its own aperture, or indirectly, through one or more cells. Deficiencies in the bony walls are not infrequent. Each ethmoid cell is small when compared with the maxillary sinus, and each is completely filled with edematous mucosa at an earlier period. The opportunity for extrusion of the mucosa and for the formation of polyps is therefore greater in the ethmoid cells than in the maxillary sinuses and probably accounts for the earlier formation of polyps in the ethmoid region.

Once the polypoid changes in the ethmoid cells are well established, activity may appear in several secondary areas. The ethmoid cells commonly drain into grooves arranged in parallel lines along the upper parts of the lateral nasal wall.<sup>4</sup> These grooves on each side, consist of the hiatus semilunaris and the bullar ostium, in the middle meatus, the posterior groove, in the superior meatus, and the postreme groove in the supreme meatus. While in one person a groove may accommodate the ostiums of several cells, in other persons it may represent a wide space for the drainage of a single cavity or cell. The ostiums of cells may sometimes be situated outside the normal grooves. The presence of these grooves explains in part the facility with which secondary polypoid formations occur after extrusion of edematous mucosa from the ethmoid cells. Eventually a series of pedunculated polyps may be attached along one or more of the grooves.

The extrusion of polyps into the superior meatus leads to abnormal contact and pressure in important olfactory areas, and where the polyps have become large they have been suspected of inducing changes in pressure in the region of the sphenopalatine ganglion. Such abnormal contacts are considered important in the precipitation of some attacks

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<sup>4</sup> Van Alyea, O. E. *Nasal Sinuses. An Anatomic and Clinical Consideration*, Baltimore, Williams & Wilkins Company, 1942.

of intrinsic asthma. In most of these instances, the tissue changes in the ethmoid cells are more important than the changes in the maxillary sinuses, because allergic edema and extrusion of polyps occur earlier in the ethmoid cells than in the maxillary sinuses.

Allergic tissue changes in the ethmoid cells have profound effects on the course of bronchial asthma, especially when they have become advanced and irreversible. Pressure may induce intrinsic asthma, and reduced nasal channels, especially in the presence of polyposis, may cause mouth breathing, air-borne allergens can then reach the lower respiratory tract directly and without filtration in the nasal chambers.

When infection of allergic ethmoidal tissue occurs, a vicious train of events follows. This tissue cannot combat infection with the same efficiency as can nonallergic tissue. The impaired response to acute infection facilitates progress to a chronic status, and chronic infection becomes established. Bacterial sensitization is then possible because of the chronic focus of infection in the ethmoid cells.

Roentgenographic examination frequently indicates very early allergic changes in the mucosa of the ethmoid cells. When minimal changes appear in the absence of purulent secretion in the usual areas of drainage, allergy is probably the etiologic factor. Later, a characteristic absorption of the thin, bony walls of the cells and a typical rarefaction of bone become of diagnostic significance. Condensation of bone is the rule in the presence of infection of the cells, and later in the course of infection, when chronicity is established, there may also be absorption. Even in chronic infection, however, the remaining areas of condensation are pronounced, and the over-all picture differs from that obtained in allergic involvement. When both allergy and infection are present, the roentgenographic findings merely indicate extensive involvement of the ethmoid cells, and the importance of each factor cannot be evaluated.

Treatment of allergic involvement of the ethmoid cells becomes necessary not only to prevent progressive tissue changes and eventual chronic infection but also because of the influence of diseased ethmoid cells on the course of bronchial asthma. Only a competent specialist can deal with the underlying factor—allergy. Neither simple nor radical surgical procedures should be considered prior to complete, systematic cutaneous tests and sincere attempts at desensitization. The local and oral use of vasoconstrictors is justified during the course of the investigation for allergy because of the temporary relief afforded the patient and also because, in some instances, such drugs may impede further changes in the tissues.

Only after it has become evident that treatment of allergy alone is unable to control, or to produce regression in, the tissue changes should surgical measures be attempted. In general, these should be

limited to the most conservative of rhinologic procedures. Removal of polyps, cauterization of polyp-bearing areas and possibly removal of the middle turbinate bone are justifiable procedures, but only if active measures are continued in an attempt to desensitize the patient or to eliminate the offending allergens.

When treatment of allergy fails and conservative rhinologic procedures are obviously inadequate, radical ethmoid exenteration is almost imperative. Such a step is justified only when extreme, irreversible tissue changes have occurred or when chronic infection has complicated the allergic reaction. Once surgical treatment has been attempted, effort should be made to eliminate every cell and to secure smooth surfaces in the area of operation. Irregular surfaces and residual cells serve to perpetuate the formation of edematous tissue and, consequently, of polyposis. Moreover, no matter how thorough surgical exenteration may be, polypoid excrescences will continue to form in the area of operation if the underlying allergy is not controlled.

Wherever possible, allergic involvement of the ethmoid cells should be managed by treatment of allergy alone. Obviously, such measures are most effective when instituted early, before extensive abnormalities have appeared in the soft tissues. Rhinologic procedures, including the most radical surgical measures, have been of no lasting value in the absence of careful investigation and treatment of allergy. Unless determined efforts are made to control the underlying allergy throughout the operative and postoperative periods, and for a long time thereafter, the results of surgical intervention will be disappointing.

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## ANESTHESIOLOGY AND OTOLARYNGOLOGY

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THE ANESTHESIOLOGIST and the otolaryngologist encounter many mutual problems. They observe many ties and much overlapping in their specialties. To achieve good results, they must understand each other's aims before, during and after every surgical procedure.

They possess something else in common—in institutional life they are frequently relegated to the back seat and assigned the most inexperienced members of the house staff. There is nothing that makes them shudder more than to see a new intern performing tonsillectomy on a patient while someone with a sheepskin in one hand is administering the anesthetic with the other. I am certain that most of my colleagues have discovered, in many an instance, that anesthetizing a patient for tonsillectomy is more difficult and exacting than anesthetizing one for lobectomy or resection of the bowel.

Theoretically, the patient should be admitted the day before operation so that he may become acclimated to the atmosphere of the hospital and properly prepared for surgical treatment. However, the critical shortage of beds has forced many institutions to admit patients for minor surgical operations on the morning on which these operative procedures are to be performed. Breakfast should be withheld, and it is imperative that the persons responsible for the patient be instructed to keep food away from him. Too many mothers, feeling sorry for their children, give them a "little" breakfast. Vomiting and aspirating the vomitus during the induction of anesthesia or postoperatively in the reactive period form the background of many a surgical tragedy.

From sixty to ninety minutes prior to surgical treatment the patient should be given either an opiate or a barbituric acid derivative in appropriate dosage and either atropine or scopolamine. A morphine salt, a codeine salt, "pantopon" (a mixture of hydrochlorides of opium alkaloids), dihydromorphinone hydrochloride and meperidine hydrochloride ("demerol hydrochloride") are frequently used. Patients who show an idiosyncrasy to morphine will frequently tolerate one of the

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From the Department of Anesthesia, Sinai Hospital

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synthetic products, "pantopon," dihydromorphinone hydrochloride or meperidine hydrochloride. The short-acting barbiturates, such as pentobarbital sodium and "seconal sodium," because of the rapidity of their action, are preferable to the longer-acting barbiturates. Morphine and allied drugs will relieve pain, but moderate doses of the barbiturates will not. Proper premedication, in addition to relieving the patient's pain or apprehension or both, will reduce the amount of anesthetic required.

Scopolamine and atropine diminish or abolish salivary secretion. Mucus can interfere with the airway by initiating laryngospasm, which not only makes the induction and maintenance of anesthesia difficult but interferes with the proper oxygenation of the patient. Furthermore, various degrees of atelectasis can be produced by the aspiration of mucus.

Atropine and scopolamine directly stimulate metabolism and therefore counteract the depression of the respiratory center produced by the sedative drugs. In addition, they depress the activity of the vagus nerve, thereby helping to protect against cardiac irregularities and laryngospasm. Scopolamine will also produce euphoria or amnesia, and that is advantageous in the proper preparation of the patient.

Should derivatives of belladonna be administered to children? This controversy has raged for some time. Anesthesiologists feel that these drugs should be used in children. Appropriate doses will not, they are certain, produce belladonna poisoning, and will certainly diminish salivary secretion. Because of the high metabolic activity of children, dangerous doses would be necessary in some instances to abolish salivary activity. However, in many cases just the diminution of the amount of mucus will be helpful.

It requires one to one and a half hours for the drugs used as premedicants to exert their maximum effect when administered subcutaneously. When given intramuscularly, they become effective within fifteen to twenty minutes. Only five minutes is necessary for the desired effect when the intravenous route is used. This avenue is helpful when the premedication has been erroneously omitted or has lost its effect. With intravenous administration, however, smaller doses should be used. The barbiturates can be given rectally in both children and adults.

Many surgeons and anesthesiologists prefer one drug or combination of drugs to others and have used them with great success. However, one must always remember that the dosage varies with the patient, the operation and the anesthesia. In choosing the dosage, the patient's age, size and occupation must be borne in mind, fever, pain, hyperthyroidism, pregnancy, alcoholism (both chronic and social), emotional excitement—all call for increased dosage, cachectic and debilitating

diseases, anemia, hemorrhage, shock, cardiorenal disease and hypothyroidism all necessitate smaller doses. When the patient is to be operated on under local anesthesia, a barbiturate should be given in addition to an opiate, not only for its hypnotic effect but also for its counteraction of any possible reaction evoked by the local anesthetic agent. If the procedure is a long one, and the premedication is wearing off, one can make the patient more comfortable by further administration of the opiate or the barbiturate or both.

TABLE 1—*Morphine and Scopolamine or Atropine*

Age	Weight, Lb	Morphine Sulfate, Grain, Mg	Scopolamine Hydrobromide, Grain, Mg	Atropine Sulfate, Grain, Mg
Up to 2 mo	7 10	1/480 (0.13 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
2-3 mo	10 12	1/360 (0.18 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
3-4 mo	12 14	1/240 (0.27 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
4-7 mo	14 16	1/144 (0.45 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
7-11 mo	16 19	1/120 (0.54 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
11-18 mo	19 24	1/108 (0.60 mg)	1/600 (0.10 mg)	1/400 (0.16 mg)
18 mo-2 yr	24 27	1/72 (0.90 mg)	1/450 (0.14 mg)	1/300 (0.22 mg)
2-3 yr	27 30	1/60 (1.0 mg)	1/450 (0.14 mg)	1/300 (0.22 mg)
3-5 yr	30 40	1/48 (1.35 mg)	1/450 (0.14 mg)	1/300 (0.22 mg)
6-8 yr	40-55	1/36 (1.80 mg)	1/300 (0.22 mg)	1/200 (0.30 mg)
8-10 yr	55-65	1/24 (2.70 mg)	1/300 (0.22 mg)	1/200 (0.30 mg)
10-12 yr	65 80	1/18 (3.60 mg)	1/200 (0.30 mg)	1/100 (0.65 mg)
12-14 yr	80 90	1/12 (5.40 mg)	1/150 (0.43 mg)	1/75 (0.86 mg)
Adult	Over 90	1/8 1/4 8 10 16 mg)	1/150 1/100 (0.43 0.65 mg)	1/75 (0.86 mg)

TABLE 2—*Meperidine Hydrochloride ("Demerol Hydrochloride")*

Age, Years	Cc	Mg
1-2	1/4	13
3-4	1/2	18
5-6	1/2	25
7-8	3/4	37
9-12	1	50
13	1 1/2	75
Adult	2	100

Tables 1 to 4, prepared by Leigh and Belton,<sup>1</sup> of Montreal, Canada, and based on a great deal of experience, may be helpful.

Many anesthetic agents and various technics of administration have been used in the field of otolaryngology. Except for rare cases, anesthesiologists do not feel that any one specific drug or technic is indicated for a certain surgical procedure. The case is a better risk when surgeon and anesthesiologist are using familiar methods, provided those methods are physiologically sound.

<sup>1</sup> Leigh, M. D., and Belton, M. K. Premedication in Infants and Children. *Anesthesiology* 7: 611-615 (Dec.) 1946.

Local and regional anesthesia have been employed with great success in otolaryngologic practice. The drug used should possess certain features. It should not be irritating to the tissues, nor should it damage nerve structure, the systemic toxicity produced should be low, the concentration needed for effective anesthesia should be low, the duration of action must be sufficiently long to permit the carrying out of the surgical procedure, the time required for the onset of anesthesia should be short, and as an ideal local anesthetic the drug should be effective when injected or when applied topically. Some of the drugs which meet the foregoing requirements and enjoy wide clinical usage are cocaine hydrochloride, procaine hydrochloride ("novocaine"), butacaine sulfate ("butyn sulfate"), "larocaine hydrochloride," "metycaine hydrochloride," tetracaine hydrochloride ("pontocaine hydrochloride") and dibucaine hydrochloride ("nupercaine hydrochloride").

TABLE 3—*Pentobarbital Sodium*

Age, Years	Grains (Mg)
1-3	$\frac{1}{4}$ (16 mg)
3-7	$\frac{1}{2}$ (32 mg)
7-12	1 (64.5 mg)
Over 12	$1\frac{1}{2}$ (96.5 mg)

TABLE 4—"Seconal Sodium"

Age	Grains (Mg)
3-6 mo	$\frac{1}{4}$ to $\frac{3}{8}$ (8-24 mg)
6-36 mo	$\frac{3}{8}$ to $\frac{1}{2}$ (24-32 mg)
3-8 yr	$\frac{3}{4}$ (48.5 mg)
8-15 yr	$\frac{3}{4}$ to $1\frac{1}{2}$ (48.5-96.5 mg)

The action of the local anesthetic agents can be prolonged by the addition of such vasoconstrictors as epinephrine hydrochloride or "cobefrin" (3,4-dihydroxy-norephedrine). When the blood vessels at the site of injection become constricted, the absorption of the anesthetic agent is delayed, thus its effectiveness is increased, and the body is allowed more time in which to detoxify the drug. This is important in cases in which sensitivity is present. Cocaine will itself produce vasoconstriction, thereby delaying its own absorption.

The inherent danger of the use of the agents producing local anesthesia lies in individual susceptibility or sensitivity. The manifestation of such sensitivity is commonly known as a cocaine or a procaine reaction. It may be mild and long in appearing or swift and tragic. Headache, vertigo, restlessness, tremors and convulsions may be seen, with death resulting from respiratory failure. The proper

and immediate treatment should be to inject intravenously "pentothal sodium" and to administer oxygen by positive pressure from an anesthetic machine. The barbiturates are almost specific in the antagonism they exert toward procaine sensitivity, and therefore they should be used prophylactically in the preparation of the patient.

The agents producing local anesthesia may also act adversely on the circulatory system, producing various degrees of collapse and shock or sudden cardiac standstill. Treatment consists in an intravenous injection of a barbiturate and administration of oxygen and a sympathomimetic agent, such as ephedrine hydrochloride or sulfate or phenylephrine hydrochloride ("neo-synephrin hydrochloride").

Some of the reactions seen with local anesthesia are due to the epinephrine in the anesthetic solution.

Because of the high incidence of accidents occurring during local anesthesia, a special committee of the American Medical Association made the following recommendations: (1) Cocaine hydrochloride and butacaine sulfate should be restricted to surface applications, (2) the total amounts of the cocaine salt used should not exceed 0.1 Gm., (3) procaine hydrochloride may be injected, but its concentration should be limited to 1.0 per cent, (4) precautions should be taken not to confuse cocaine hydrochloride and procaine hydrochloride, as a number of fatalities have resulted from this error.

I have tried to stress individual susceptibility to the drugs producing local anesthesia, because too often minute quantities will produce severe reactions. Furthermore, some of one's ideas concerning procaine and associated drugs have received a jolt in the past two years. The British and the Canadians have been injecting procaine hydrochloride intravenously for the relief of pain in severe burns and for postoperative pain. In this country intravenous use of this drug has saved lives by dramatically correcting cardiac irregularities in patients undergoing surgical treatment for pulmonary and cardiac conditions. Frederick Allen, of New York, reported that he had used it successfully in obstetric practice without observing any untoward result in mother or infant.

In an effort to avoid accidents one should question each patient closely as to previous experience with local anesthesia and make a cutaneous or a mucosal test of the drug to be used whenever possible. A mucosal test is made by applying a small quantity of the drug to the mucous membrane; if no systemic reaction has appeared within ten minutes, that agent is considered relatively innocuous in that patient.

Proper local anesthesia, obtained by either a topical application or a regional nerve block or a combination of both, will permit many procedures to be done on the head or the neck of the well premedicated patient. To become proficient in nerve blocking, one should be well

acquainted with the anatomy of the region in which nerve block is to be achieved and should not be disheartened by early failures. Furthermore, the surgeon must realize that his operative time is limited by the duration of the anesthesia, and his patient's comfort may last only as long as the sedation. However, if need be, both anesthetic and sedative can be administered again.

In many instances the operative procedure or the desires of the patient or of the surgeon may warrant general anesthesia. First, the anesthesiologist and the surgeon must ask themselves, "Should this patient be put to sleep?" I can vividly recall a case in which I was involved during my training.

An obese lady in her early thirties was to undergo a pelvic laparotomy for uterine fibroids. Nothing in her history foretold any difficulties relative to anesthesia. Several minutes after the induction I heard gurgling and bubbling noises coming from her mouth. The face mask was removed, and there was fresh blood pouring from her nose and mouth. Suction was begun immediately, the patient being placed in the Trendelenburg position, and the operation was canceled. I soon realized that a nose bleed was the problem, it was controlled by packing and the patient was returned to her room. She later confessed that she frequently had nosebleeds but had forgotten to mention this minor fact to the house staff. The operation was done forty-eight hours later, with this patient under spinal anesthesia.

I should like to recall another case.

A colleague of mine was called one afternoon to administer a "little pentothal sodium" to a patient who was to undergo incision and drainage of the site of Ludwig's angina (cellulitis of the floor of the mouth). The anesthesiologist requested that a preliminary tracheotomy be done. The request was refused. A few cubic centimeters of "pentothal sodium" was administered, and suddenly the patient stopped breathing. All efforts at resuscitation failed.

When one is dealing with a tumor or an inflammation of the neck or the nasopharynx one must be certain that the airway will be adequate once anesthesia has been established. Pressure, collateral edema or obstructive size of the tumor or the abscess may be producing moderate respiratory distress prior to anesthesia. Too frequently hypoxia and anoxia appear when the patient is asleep unless a proper airway has already been established. This can be done either by preliminary tracheotomy or by nasotracheal intubation under topical anesthesia. A laryngoscope with a thin blade and a pair of long curved forceps to direct the tube are essential for intubation. These instruments should be used with great gentleness.

After a suitable airway has been established, light anesthesia, induced with either "pentothal sodium" or any of the gaseous agents, can be employed. If it is a tumor that is being removed, deeper anesthesia will be necessary. If an intraoral abscess is to be opened, anesthesia

light enough to preserve the cough reflex and a steep Trendelenburg position are indicated. The mortality rate in cases of Ludwig's angina runs from 50 to 60 per cent. The necessity for teamwork is obvious.

Of all the anesthetic agents at the command of the anesthesiologists and the surgeon, ether U S P is still the standard and certainly the most popular one. The ease of its administration and the great margin of safety are important factors. All, however, have been disturbed by the screaming of the young patient during induction, and certainly none would think of administering "straight" ether to an adult. Nitrous oxide U S P, ethylene or cyclopropane U S P can be used for induction with both children and adults, "pentothal sodium" may be used with patients over 10 years of age. My associates and I have found ethyl chloride and vinyl ether, or "vinethene," administered by the open drop technic, to be suitable for children. Both agents are more potent and less irritating to the olfactory sense and the pulmonary tree than ether. We have also found them useful in short otolaryngologic procedures. However, because of their potency, they must be handled with great care and caution. Vinyl ether, which is an unsaturated ether, has a wider margin of safety than ethyl chloride and therefore is the safer agent.

I should like to interject one word of caution. A few weeks ago I was called to anesthetize a child for the suturing of a laceration. Just as I was about to begin, I noticed the youngster's jaws working rapidly. I held out my hand and said, "Let me hold that chewing gum for you, sonny." Thereupon I became the proprietor of the "bubble gum." Children are fond of placing foreign objects in their mouths, particularly candy or chewing gum. This should be remembered prior to anesthesia. During anesthesia one should be careful of any loose teeth or dentures of children or adults. A well fitting denture which one knows is present should not cause any concern.

There are many machines and devices, some complicated and some simple, for the administration of ether for adenotonsillectomy. Essentially, all are designed to pass air or oxygen through ether to the patient's oropharynx. However, it is possible, if the apparatus is set up incorrectly, for liquid ether to be sucked into the patient's mouth. Tragedy can occur before one is aware of what has gone wrong. It is the sole responsibility of the anesthesiologist to check the apparatus before each and every use.

In an effort to keep blood and mucus away from the glottis during the operation, my associates and I have resorted to the effects of gravity that are gained by the Trendelenburg position. This will decrease the danger of aspiration, of blocking of the glottic orifice by accumulated blood, and of laryngospasm in cases in which only a slight amount of blood or mucus will produce abduction of varying degrees of the vocal cords and eventually oxygen lack.

To maintain an adequate airway, various gags and tongue depressors have been used. The Davis gag which is so frequently used can be held by the anesthesiologist. Thus there is no need of a good assistant to hold the loose type of blade. Too often, the loose blade is handed over to someone who has little notion of how to hold the instrument properly. Thereupon, the tongue and blood encroach on the airway, and the surgeon and the anesthesiologist struggle for proper exposure and adequate oxygenation. When the proper-sized blade is attached to the Davis gag, the tip of the blade will fit into the hypopharyngeal sulcus and the tongue will be sufficiently depressed to insure an adequate airway.

A careful check should be kept of the sponges placed in the mouth or the nasopharynx.

As the adenotonsillectomy is nearing completion, anesthesia should be lightened considerably, so that the cough reflex can be elicited to expel some of the foreign matter in the tracheobronchial tree. At the conclusion of the procedure, the patient should be placed on the stretcher in a semilateral position with the head extended and the upper leg flexed. The same position should be used when the patient is transferred to his bed. The tongue will tend to fall forward, and blood and secretions will not collect near the glottis. Furthermore, should the patient cough or vomit, the oral contents will be expelled onto the bed, whence the patient cannot aspirate them. About two years ago an infant was operated on for harelip and cleft palate, after completion of the dressings, the child was placed on its back and its hands were tied so that it would not pick at its bandages. During the period of recovery, the child vomited, aspirated and died before anything could be done. The reason anesthesiologist and surgeon are so concerned about an active cough reflex, position and aspiration is because of the possibility of atelectasis, bronchopneumonia and pulmonary abscess. Bronchoscopic studies following tonsillectomy have shown that as many as 78 per cent of these patients will have blood in the tracheobronchial tree in spite of the prophylactic measures. Given the organisms found in infected tonsillar crypts, the proper culture medium in the dependent portion of the bronchial tree and lowered resistance, one may well be surprised that the incidence of pulmonary abscess is not higher in these patients.

During the past three years my associates and I have had some interesting experiences relating to anesthesia induced with "pentothal sodium" in adults who were to undergo tonsillectomy. We have not used this drug in children under 10 years of age, because of our belief that in these patients the margin of safety is not great enough. The strength of the solution used ranges from 1.25 to 2.5 per cent. As

soon as the patient is profoundly asleep, the Davis gag is inserted. The operator should not begin until the throat muscles are quiet and the pharyngeal reflex is abolished, otherwise, the stimulation produced may make it difficult to maintain smooth anesthesia. A piece of rubber tubing, connecting the anesthesia machine to the Davis gag, carries equal parts of oxygen and nitrous oxide. This mixture will furnish additional oxygen to the patient and will reduce the amount of "pentothal sodium" needed. For maintenance, "pentothal sodium" is administered intermittently as needed. The patient's color and the diaphragmatic movements are closely observed. At the end of the operation a breathing tube is placed in the mouth to maintain an adequate airway until the pharyngeal reflexes have returned. Between 10 and 15 Gm suffices for the average patient. Occasionally 20 Gm has been necessary.

The most troublesome complication has been laryngospasm. Usually this was overcome by temporarily stopping the operation, suctioning all blood and secretions from the throat and administering more "pentothal sodium." Some physicians have been routinely cocaineizing the throat just prior to surgical procedure to prevent laryngospasm and to diminish the amount of "pentothal sodium" required. We have felt that obtunding the patient's reflexes would increase the likelihood of postoperative pulmonary complications, and, therefore, we have refrained from this practice. However, in several cases in which the laryngospasm was severe enough to produce hypoxia we have applied sponges medicated with 2 per cent tetracaine hydrochloride to the tissues surrounding the tracheal orifice. This procedure has been of some aid. In several cases the spasm was ameliorated by small divided doses of curare. If these maneuvers should fail, a nasotracheal tube should be inserted and the trachea packed off so that foreign matter will not run along the tube and into the trachea. When one is faced with a heavy, thick, short-necked patient, one can insert the tube before the operation is begun and thereby insure a good airway and smooth anesthesia. The tube should not be removed until the patient is almost awake.

The average patient reacts and becomes rational in about thirty minutes. Caffeine and sodium benzoate injection U S P (0.5 Gm [7.5 grains]) may be administered intramuscularly if the patient is sleeping too long.

The endotracheal tube can be and should be used more frequently for tonsillectomy. McCarthy<sup>2</sup> reported 1,550 cases in which tonsillectomy was performed on adults anesthetized by endotracheal administration of nitrous oxide. Whenever the surgeon and the anesthetist find that they cannot correct persistent hypoxia, intubation should be performed. One should remember that cerebral changes produced by inadequate oxygenation can never be corrected.

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2 McCarthy, K. C. Endotracheal Nitrous Oxide Anesthesia for Tonsillectomy, *Anesthesiology* 1 216-222 (Sept.) 1940



The endotracheal tube should also be used in otolaryngologic procedures in which the anesthesiologist is "draped out of the field," or in which he has no control of the airway once surgical operation has begun, or in which there is likelihood of aspiration of foreign or infected matter. Depending on the site of the operation, the orotracheal or the nasotracheal technic may be followed. A tube with an inflatable cuff should be used whenever one wishes to seal off the tracheobronchial tree and prevent aspiration. At the conclusion of the operation, all secretions, blood and pus are suctioned off, the cuff is then deflated and the tube removed. Whenever indicated, the tube should be allowed to remain until the patient is fully awake. During the war this proved to be a life-saving measure in personnel with severe facial, oral and cervical injuries. Many a technic or variation thereof has been advanced as the ideal method of securing anesthesia for extensive laryngeal operations. I believe that the ideal setup for laryngeal operations is a cooperative surgeon, a competent anesthesiologist and a cuffed endotracheal tube.

The drug that has fascinated many anesthesiologists and surgeons is curare. Curare, which is a derivative of the plant *Strychnos*, has gained widespread usage in general surgical practice because of its ability to relax striated muscle. Prostigmine is the physiologic antidote. Curare has been found to be valuable in endoscopic practice. There are occasions when, in spite of premedication and good topical anesthesia, enough relaxation cannot be obtained for bronchoscopic or esophagoscopy procedures. At such times a small dose of curare (20 mg for a child and 50 to 60 mg for an adult) given intravenously may produce the extra amount of relaxation needed. If required, additional curare may be administered in very small doses. However, my associates and I feel that curare, because of its potency, should be used only in institutions and by someone familiar with the drug and with the technic of controlled breathing.

In conclusion, I should like to reiterate the necessity for greater cooperation and understanding between otolaryngologists and anesthesiologists. Then they will achieve better anesthesia and finer surgical results, with fewer complications.

# EFFECT OF DIFFERENTIAL MOBILITY OF THE WINDOWS OF THE COCHLEA ON THE MECHANISM OF HEARING

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**I**N ORDER to explain many of the unanswered questions pertaining to the functioning of the mechanism of the ear as it pertains to practical otologic diagnosis, the following hypothesis has been propounded. The basis for it was initially presented by von Békésy<sup>1</sup> in his original work on the reception of sound by bone conduction.

## INITIAL CONCEPT

First, one may look on the cochlea as being made up of two ideally symmetric cavities, separated by a uniformly flexible basilar membrane except for an analogous helicotrema and terminated in two similar membranous windows having the same elastic properties. This concept is diagrammatically shown in figure 1A, which depicts a cross section. Now, if the bony side walls of such a cavity were made to vibrate by a source of sound applied to the skull containing such a cochlea, it should be evident that the side walls would be alternately compressed and released, that is, they would move in and out between the solid and the broken lines (diagrammatically this movement has been exaggerated for sake of clarity). Such motion would produce corresponding compression and expansion of the fluid in each compartment of the cochlea, with the result that the liquid pressures in each compartment would remain equal. This means that the same normal force is exerted on all analogous sides of each compartment. In the case of the basilar membrane these forces are equal and opposing one another, therefore there is no resultant displacement of the membrane. However, in the case of the elastic windows these forces are acting in

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1 von Békésy, G. Zur Theorie des Hörens bei der Schallaufnahme durch Knochenleitung, *Ann d Physik* **13** 111, 1932

the same direction, and, as the windows are extremely flexible as compared to the bony side walls, each is displaced outwardly to the same degree

In the event that the membrane of one window of such a cochlea, say the upper, is less elastic than that of the other, it should be apparent that a greater displacement of the more elastic window will occur for the same applied force. When the side walls of the compartments containing such windows are stimulated as before, a momentary increase in the pressure of the liquid of the upper compartment relative to the lower will result, since the compartments no longer have a symmetry of elasticity. However, when a difference of pressure exists in such compartments, there is an automatic tendency to bring the acting forces to equilibrium at any instant, this tendency actually involves the simultaneous motion not only of the two windows (the outward motion

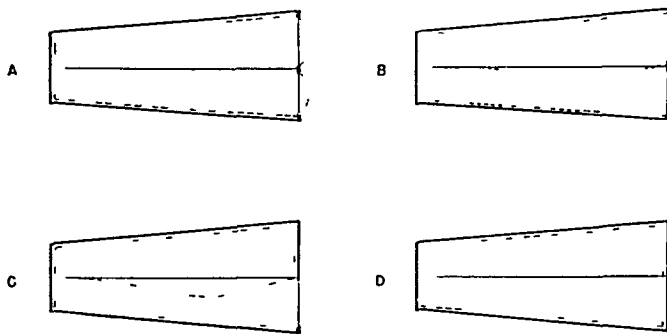


Fig 1—Illustrations of a simple concept of the cochlea. The solid lines represent the outlines of the scalae during the steady state, the broken lines represent those during the excited state

of which merely tends to decrease the pressure of the liquid in the compartments) but also of the mobile basilar membrane. In this particular example the lesser of the two forces acting on the basilar membrane would be on the under side, hence the membrane would be displaced downward in order to satisfy these conditions of equilibrium. The resultant displacement of the membrane, corresponding as before to the maximum positive excitation of the cochlea would be as shown in figure 1B.

The third possibility is the complete blocking of, say, the upper window by bony structure. In accord with reasoning similar to that used in the preceding examples, it is obvious that the result would be a maximum displacement of the basilar membrane and of the lower window, as shown in figure 1C. If the cochlea were completely encased in bony structure, as in figure 1D, the resultant stimulation of the basilar membrane would be the same as for the concept of the cochlea in figure 1A.

The reader should note at this point that in the presentation of this work only the crest of the exciting cycle is considered and that the frequency of the exciting source is such in each example as to produce a maximum displacement of the basilar membrane at the point shown, in accordance with the resonance theory of hearing

#### HUMAN ACTUAL COCHLEA

The consideration of the human cochlea (fig 2) must account for the following factors (1) the added effect of the attached semicircular canals to the upper compartment, or scala vestibuli, and (2) the difference between the oval and the round window

According to a reasoning similar to that applied to the simple cochlea, if the human cochlea were excited in a fashion like that previously described, the only modification of the results would be one due to the additional fluid attachment of the labyrinth, this would

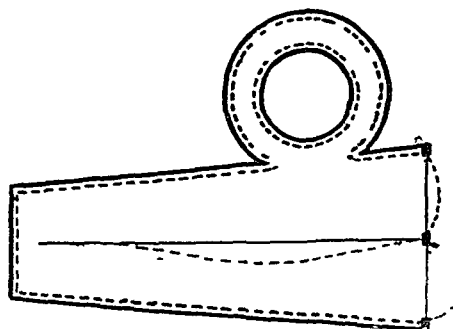


Fig 2—Diagrammatic representation of the human cochlea. Outlines of the scalae during the steady state are represented by the solid lines, in the excited state, motion due to air conduction is shown by the dotted line, and that due to bone conduction, by the broken line

create a greater pressure of fluid in the scala vestibuli than in the scala tympani. The effect would be that of an added downward displacement of the basilar membrane, analogous to its movement in the simple cochlea previously considered in this paper. Why it would take place is seen when the relative elasticity of the membranes of the round and oval windows with respect to the basilar membrane is considered. Until this point the basilar membrane has been considered as being a separating medium only, with perfect freedom of motion or elasticity. Practically, this state is an impossibility. Since the dynamics of the inner ear have not been determined, it would appear most likely that the motion of the basilar membrane would be combined with that of the round window in order to assure that they both have the same elasticity or freedom of motion. An accepted fact, however, is that the elasticity of the round window is greater than that of the oval window. This may be appreciated by observation of the differ-

ence in shape and the attachment of the stapes to the oval window. That is to say, the mobility of the windows differs. It is this differential of mobility between the oval and the round window which is the significant factor in the determination of the magnitude of the resultant stimulation by the motion of the rods of Corti on the basilar membrane of the neural elements leading to the brain.

So far only the excitation of the cochlea by the bony side walls encasing the same (bone conduction) has been considered. To complete the picture, a consideration of the effect of excitation of the cochlea by the ossicular-tympanic pathway (air conduction) must be included. By convention, the positive crest of a sound wave acting on the ear drum membrane forces the stapes and the membrane of the oval window inward. Since the endolymph and the perilymph are incompressible, and the bony side walls of the cochlea are immobile under such excitation, the inward motion of the oval window can be compensated for only by the outward motion of the round window and the downward displacement of the basilar membrane, as shown in figure 2. By comparison of the relative motion of the window for bone conduction (broken lines) with that for air conduction (dotted lines) the difference in the magnitude of the stimulation can be seen in terms of the displacement of the basilar membrane. Therefore, it should be apparent that, the greater the differential between the position of the windows at rest (solid lines) and their maximum excursion (positive or negative) when excited, the greater is the stimulation of the basilar membrane. From this conclusion it would appear that, for the normally functioning ear, in order that the same apparent stimulation would result when the inner ear was excited by bone conduction as when it was excited by air conduction, a loss of fluid pressure by the oval window would have to be prevented by the reflex action of the intra-aural muscles, holding the stapes relatively fixed and thereby approaching the condition shown in figure 1C, as otherwise as great a stimulation by bone-conducted sound as by air-conducted sound would be impossible.

#### CLINICAL VERIFICATION

The application of this hypothesis to the impaired ear readily explains many of the observed phenomena. In the case of stapedial ankylosis, in which there is a natural blocking of the oval window, lowering of the threshold of bone conduction can be expected, as the differential mobility of the two windows has been increased to a practical maximum. This has often been observed in the impaired ear and produced artificially by fixation of the stapes.

In the case of the normal ear, if a sufficient difference in pressure is obtained between the middle and the outer ear, it is possible effec-

tively to reduce the threshold of hearing not only by bone conduction but also by air conduction, to a great degree. That is, when increased pressure of the middle ear from either liquid or air, as in altitude changes, effectively blocks or prevents the motion of both windows, the same phenomenon results as has been often observed when the middle ear is occupied with scar tissue.

In a radical mastoidectomy, for example, the formation of scar tissue on the internal wall of the middle ear inevitably reduces the

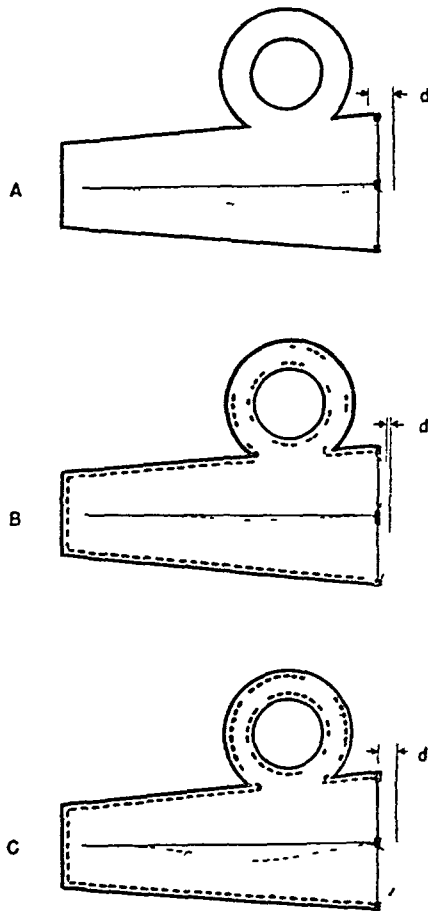


Fig 3—Diagrammatic representation of the human cochlea, showing hypothetical responses to air conduction and bone conduction under certain conditions. The solid lines show outlines in the steady state, the dotted lines, those during the excited state due to air conduction, and the broken lines, those during the excited state due to bone conduction.

threshold of hearing. In view of the foregoing explanations, the reason should be evident. It could be added, however, that a considerable increase in the ability to hear can be made by the simple addition of an artificial drum in the external auditory meatus, with an attached prosthesis touching either window.

With reference to the reasoning given for excitation of the cochlea by air conduction, it is possible to explain some forms of the paradoxical

situation encountered in which the reception by air conduction is better than that by bone conduction in terms of the average normal ear. Should the membrane of the round window be made slightly immobile, owing to thickening or foreign obstruction, for example, then for air conduction the relative motions of the membranes would be as shown in figure 3A, with a differential between the windows ( $d$ ), while the motion for excitation by bone conduction would be as shown in figure 3B, where the differential is seen to be practically nonexistent for an outward motion of the oval window and approximately one-half that for air conduction, figure 3C, if the stapes is held fixed at its point of rest. Thus a possible explanation of the phenomenon is revealed.

From the standpoint of the selection of cases most suitable for the fenestration procedure, it is well to consider that the filling in of the niche of the round window with scar tissue or a bony structure due to malignant otosclerosis would result in apparent perceptive deafness, a deafness not necessarily present unless such a condition affected the nerve and the functioning parts of the inner ear from atrophy of disuse over an extended period.

The realization that an apparent perceptive deafness may result from the immobility of the windows of the inner ear opens a new field of otologic diagnosis.

#### CONCLUSION

The presentation of this hypothesis and its practical illustrations is made in the interest of otology as a further aid to the diagnostician and also to the research worker in understanding how the mechanism of the ear functions.

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# LOCAL STREPTOMYCIN THERAPY FOR SUPPURATIVE OTITIS

Bacteriologic and Clinical Observations

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CHRONIC suppurative otitis media is a fairly common and sometimes serious disease. In addition to the persistent discharge, which is often foul smelling and disagreeable, there may be serious complications and sequelae, including deafness, meningitis and abscess of the brain. The known treatment of chronic otitis media is far from satisfactory. Conservative types of therapy involve cleansing and drying of the middle ear and instillation of various antiseptics, sulfonamide drugs or penicillin<sup>1</sup>. These are successful in some instances, but many patients are benefited only by appropriate surgical measures.

Collins and Hughes<sup>1a</sup> studied the bacterial flora of 26 ears of 23 previously untreated patients with chronic otitis media and observed that gram-negative bacilli were more frequently present than gram-positive cocci. Repeated cultures of flora from the middle ear cavities of certain patients treated locally with penicillin revealed a complete change from the original, predominantly gram-positive organisms, sensitive to penicillin, to gram-negative bacilli, resistant to penicillin. They concluded that "the presence of the secondary organisms such as the coliform bacteria, *Proteus vulgaris* and diphtheroids was undoubtedly one of the complicating factors limiting the successful treatment of chronic suppurative otitis media with penicillin."

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This study was aided by a grant from the United States Public Health Service.

From the Thorndike Memorial Laboratory, Second and Fourth Medical Services (Harvard), the Mallory Institute of Pathology, Boston City Hospital, and the Department of Medicine, Harvard Medical School.

1 (a) Leech, M P, Bloom, W A, Coffman, D L, and Shaw, W J. Treatment of Chronic Purulent Otitis Media with Sulfathiazole Crystals, *J Missouri M A* **40** 292 (Sept) 1943. (b) Heatley, C A. Chronic Diseases of the Nose, Throat and Ear, *M Clin North America* **28** 330-338 (March) 1944. (c) Banham, T M. Conservative Treatment of Chronic Suppurative Otitis Media in Adults, *J Laryng & Otol* **59** 117-135 (April) 1944. (d) Collins, E G, and Hughes, K E A. Treatment of Chronic Suppurative Otitis Media by the Local Application of Penicillin and Other Drugs, *ibid* **59** 81-95 (March) 1944. (e) Williams, H J. Chronic Suppurative Otitis Media, *Pennsylvania M J* **48** 1159-1161 (Aug) 1945.



Bacteriologic studies of the aural discharge in cases of otitis externa also reveal the prominent role of gram-negative bacilli in these infections. *Pseudomonas aeruginosa* was the predominant organism in 45 of 100 consecutive cases reported by Salvin and Lewis<sup>2</sup>. In another study,<sup>3</sup> of 72 ears, the same organism was found in 67 per cent, other gram-negative bacilli were cultured in 17 per cent. Such organisms were also noted in other cases of otitis externa, and the failure of local and parenteral penicillin therapy has been ascribed to their presence in the exudate.<sup>4</sup>

It thus appears that both otitis media and otitis externa are frequently caused by, or at least are associated with, gram-negative bacilli which are not susceptible to penicillin and which are affected little, if at all, by sulfonamide drugs. These organisms are sensitive to streptomycin, however, and a clinical trial of this antibiotic in cases of otitis with susceptible organisms seemed warranted.

One of the most important factors which limit the effectiveness of streptomycin against many infections is the rapid development of resistance to the antibiotic by the infecting organisms. In vitro the production of strains resistant to antibacterial agents is best accomplished by repeated subcultures of the organisms in mediums containing increasing, but sublethal, concentrations of the agents. It is also possible in some instances to produce resistant strains in vivo by treating certain experimental infections with subeffective amounts of these agents. It is therefore generally assumed that the development of resistant strains during therapy could be avoided by the use of doses large enough to maintain concentrations of the antibacterial agents well in excess of the minimum amount required to inhibit the growth of the organism.

It is important to determine the validity of this assumption, both from the point of view of practical therapeutics and because of the light such knowledge might shed on the mechanism of the development of resistance by bacteria. In systemic therapy one cannot be certain of maintaining adequate concentrations at the site of the infection. That should be possible, however, with topical applications in cases of certain types of accessible focal infections. Local streptomycin therapy for suppurative infections of the ear caused by strains of bacteria sensitive to that agent would seem to offer suitable conditions for such a test. This method of treatment was therefore chosen, and

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2 Salvin, S. B., and Lewis, M. L. External Otitis, with Additional Studies on the Genus *Pseudomonas*, *J. Bact.* **51** 495-506 (April) 1946.

3 Syverton, J. T., Hess, W. R., and Krafchuk, J. Otitis Externa. Clinical Observations and Microbiologic Flora, *Arch. Otolaryng.* **43** 213-225 (March) 1946.

4 Senturia, B. H. Treatment of External Otitis. Local Sulfonamide Therapy, *Laryngoscope* **54** 277-280 (June) 1944, Penicillin Therapy in External Otitis, *Ann. Otol., Rhin. & Laryng.* **55** 90-107 (March) 1946.

a limited study was undertaken to determine its effect on the flora and on the clinical course of such infections. The results of bacteriologic and clinical observations made on 27 suppurating ears in 18 patients are the subject of this report.

#### MATERIALS AND METHODS

*Selection of Patients*<sup>5</sup>—The 18 patients selected for local streptomycin therapy had persistent aural discharges which on culture yielded organisms sensitive to streptomycin. Six of the patients were treated in the hospital and the rest as outpatients. The infections involved one ear in each of 9 patients and both ears in the rest—a total of 27 suppurating ears. For convenience, data on these ears were tabulated in three groups, as follows (tables 1 and 2).

Group 1 (ears 1-5, in 5 patients). The patients were admitted to the aural service of the Boston City Hospital for acute suppurative otitis media. In each of these patients fever and pain subsided soon after admission to the hospital, but a profuse, foul-smelling discharge persisted from one to six weeks in spite of continuous treatment with local and parenteral administration of penicillin, oral administration of sulfadiazine and irrigation with hydrogen peroxide. One of these patients also had chronic otitis media of the other ear; it is included as ear 6 in group 2.

Group 2 (ears 6-24 in 12 patients). Purulent discharge from these ears had persisted or recurred frequently over periods of from one to twenty-five years. Otoloscopic examination in each instance revealed perforation or absence of the tympanic membrane and a purulent discharge from the middle ear. Mastoidectomy had been done on 5 patients, and roentgenograms indicated changes consistent with chronic mastoiditis in 5 others.

Group 3 (ears 25-27, in 2 patients). The patients had chronic suppurative otitis externa. In 1 of them both ears had drained profusely for two months, and in the other the left ear had had slight but persistent drainage for sixteen months. Otoloscopic examination in each case revealed a red and inflamed wall of the external auditory canal, but a normal and intact tympanic membrane.

*Bacteriologic Studies*—Cultures of the aural discharge were made on one or more occasions before the streptomycin treatment was begun and were repeated at intervals during and after the course of therapy. The cultures were made by inserting a sterile cotton swab deep into the external auditory canal and streaking the tip of the swab on the surface of nutrient agar containing 10 per cent horse blood. The tip of the swab was then placed in a tube of nutrient broth, from which subcultures were made on other blood agar plates. Individual colony types were subcultured on fresh blood agar plates, and the various strains were then identified from pure cultures on the basis of their morphologic, cultural and biochemical characteristics. Tests for the sensitivity of these strains to streptomycin<sup>6</sup> were carried out on broth cultures by a serial dilution method, the details of which have been given elsewhere.<sup>7</sup>

5 Drs. Solomon Steinman, Sidney Wilker, Irving F. Gregorv, Alfred Blouin, Chester Goodnow, Raymond Conway and Daniel F. Shea, all of the Aural Service of the Boston City Hospital, made follow-up observations on these patients.

6 Miss Marion E. Lamb, of the Mallory Institute of Pathology, assisted in the identification and classification of the various strains. Miss Clare Wilcox made the tests for sensitivity.

7 Harris, H. W., Murray, R., Paine, T. F., Kilham, L., and Finland, M. Streptomycin Treatment of Urinary Tract Infections with Special Reference to the Use of Alkali, *Am. J. Med.* 2: 229-250 (March) 1947.

TABLE 1—Summary of Bacteriologic Observations and Clinical Responses in Cases of Suppurative Otitis Treated with Topical Applications of Streptomycin Solutions

Before Streptomycin Therapy										Local Streptomycin		During Streptomycin Therapy			Results and Comment	Duration of Follow-up Observation
Ear	No	Side	Duration of Drainage	Organisms	M I C *	Units per Cc		Days	Drainage	Organisms	M I C *	Drainage	Organisms	M I C *		
Group 1																
1	Left		6 wk	Proteus vulgaris	50	10,000	4	14	Stopped in 9 days	P vulgaris	50	Stopped in 9 days	Staph albus	12 5	Cultures sterile after 3 days, ear remained dry	6 mo
2	Left		4 wk	Pseudomonas aeruginosa	50	5,000	6	12	Stopped in 4 days	None		Stopped in 4 days	None		Ear remained dry	2½ mo
3	Left		3 wk	Ps aeruginosa	200	5,000	6	14	Stopped in 8 days	Ps aeruginosa	>50,000	Stopped in 8 days	P vulgaris	>50,000	Cultures sterile after 12 days, ear remained dry	3 mo
4	Right		1 wk	P vulgaris	100	10,000	8	9	Temporarily reduced	P vulgaris	100	Temporarily reduced	P vulgaris	100	Acute mastoiditis eighth day, mastoidectomy ninth day, second course of streptomycin begun 18 days later, resistance developed next day, no clinical improvement	3 mo
			4 wk	P vulgaris	100	10,000	8	18	Persisted	P vulgaris	>50,000	Persisted	P vulgaris	>50,000		
5	Right		2 wk	P vulgaris	50	1,000	6	14	Stopped in 8 days, recurred	Ps aeruginosa	>50,000	Stopped in 8 days, recurred	A faecalis	12 5	Discharge recurred 1 wk after therapy, cultures then yielded only A faecalis	3½ mo
Group 2																
6	Left		15 yr	Ps aeruginosa		1,000	6	14	Stopped, recurred	Ps aeruginosa	>50,000	Stopped, recurred	A faecalis	3 1	Same patient as ear 5, discharge recurred 1 wk after therapy stopped, with cultures yielding only A faecalis	3½ mo
7	Left		14 yr (recurrent)	Klebsiella pneumoniae, type A Staphylococcus albus	1 6 6 3	25,000	3	13	Stopped in 3 days	None		Stopped in 3 days	None		Ear remained dry, patient treated for pneumonia with intramuscular injections of streptomycin, reported as case 4 by Harris and others (New England J Med 236 611 622 [April 24] 1947)	3 mo
8	Left		20 yr	P vulgaris	50	5,000	4	15	Stopped	A faecalis	12 5	Stopped	A faecalis	12 5	Ear remained dry after 2 days	4 mo
9	Right		20 yr	Staph albus		5,000	4	15	Stopped	Gram negative bacillus	5,000	Stopped	Gram negative bacillus	5,000	Same patient as ear 8, ear remained dry after 5 days	4 mo
10	Right		25 yr	Ps aeruginosa	50	10,000	4	7	Stopped	Ps aeruginosa	12 5	Stopped	Ps aeruginosa	12 5	Ear remained dry after 1 day	3 mo
11	Left		25 yr	Ps aeruginosa	50	10,000	4	7	Stopped in 2 days	Ps aeruginosa	12 5	Stopped in 2 days	Ps aeruginosa	12 5	Same patient as ear 10, ear remained dry	3 mo

12	Right	8 yr	Ps aeruginosa Staph albus	100 50	12,500	4	6	Stopped in 2 days	Diphtheroids	Lar remained dry	2 mo
13	Left	10 yr	Alcaligenes faecalis	125	10,000	4	14	Stopped	None	Lar remained dry after 4 days	1 wk
14	Right	10 yr	Streptococcus lactis Diphtheroids	63 16	10,000	4	11	Persisted	Str lactis Staph albus	Same patient as ear 13, drainage of foul pus continued	4 wk
15	Right	17 yr	Staph aureus	32	10,000 P 500†	4	51	Stopped in 15 days	A faecalis	Cultures became sterile during treatment, ear remained dry	5 mo
16	Left	15 yr	P vulgaris A faecalis	125 50	10,000 P 500†	4	51	Persisted	P vulgaris A faecalis	Same patient as ear 15, later cleared after 1 week of oral and local sulfonamide therapy	5 mo
17	Right	1 yr	P vulgaris	50	5,000	4	14	Stopped in 14 days	P vulgaris	Ear remained dry	None
18	Left	1 yr	P vulgaris	500	5,000 P 500†	4	21	Stopped in 9 days	P vulgaris	Same patient as ear 17, ear re mained dry	None
19	Left	21 yr	Hemolytic Staphylo coccus aureus Ps aeruginosa Gram negative bacillus Diphtheroids	125 25 63 5,000	1,000 P 500†	4	8	Stopped in 2 days	Gram negative bacillus	Ear remained dry, signs and symptoms of acute mastoiditis began 1 week after treatment ended, but subsided without fur ther therapy in 2 days	5 mo
20	Left	3 yr	Ps aeruginosa	25	12,500	4	22	Stopped in 14 days, recurred	Staph albus	Discharge recurred 1 week after therapy ended, persisted	3 mo
21	Right	5 yr	Ps aeruginosa	200	12,500	4	17	Stopped, recurred	Ps aeruginosa	Ear dry for 2 weeks, discharge then recurred, M I O 25 on third day, >50,000 on sixth day and thereafter	1 mo
22	Left	5 yr	Ps aeruginosa	200	12,500	4	17	Stopped recurred	Ps aeruginosa	Same patient as ear 21, organism resistant on third day	1 mo
Group 3											
23	Right	1 yr	K pneumoniae	63	1,000	4	19	Persisted	Staph albus	Discharge after treatment yielded Ps aeruginosa, M I O 100	4 mo
24	Left	1 yr	K pneumoniae	63	1,000	4	19	Persisted	K pneumoniae A faecalis	Same patient as ear 23, discharge after treatment yielded Ps aeru ginosa, M I O 100	4 mo
25	Right	2 mo	Ps aeruginosa	100	12,500	4	12	Stopped for 10 days	Ps aeruginosa	Culture normal on second day, yielded pathogens on fifth day, resistant strain persisted	1 mo
26	Left	2 mo	Ps aeruginosa P vulgaris	100 50	12,500	4	12	Stopped for 10 days	Ps aeruginosa	Same patient as ear 25, organism totally resistant after fifth day	1 mo
27	Left	10 mo	Ps aeruginosa Staph albus	50 25	20,000 P 500†	4	10	Stopped in 2 days	Yeast	Ear remained dry, healed	2 mo

\* Minimum inhibiting concentration of streptomycin (i.e., sensitivity), units per cubic centimeter of culture

† Penicillin incorporated in streptomycin solution, units per cubic centimeter

*Therapy*—All the patients received the streptomycin in local instillations except for 1 patient, who was also given intramuscular injections of streptomycin for chronic bronchiectasis. The streptomycin solutions were made up in 10 to 20 cc amounts of the desired concentration in sterile isotonic sodium chloride solution and were kept in a refrigerator when not in use. The concentrations of streptomycin most frequently used were 5,000 to 12,500 units per cubic centimeter, but some patients received 1,000, and other 20,000 or 25,000, units per cubic centimeter. Penicillin, in a final concentration of 500 units per cubic centimeter, was incorporated in the solution for instillation in 4 ears, from 3 of which staphylococci had been obtained in the pretreatment cultures.

The external auditory canal of the affected ear was wiped thoroughly with dry, sterile cotton swabs before each instillation. The head was then held with the ear upward and with the canal in a vertical position. With a clean, though not sterile, medicine dropper, about 1 cc of solution was instilled drop by drop into the canal, which was then plugged with sterile cotton. The head was kept in the same position for from three to five minutes. These treatments were carried out from six to eight times a day by the nursing staff on the 6 patients who were hospitalized. The remaining 12 patients carried out this procedure at home, usually four times daily. The duration of the therapy varied from six to fifty-one days. If the drainage subsided promptly, the instillations were usually discontinued after a week, but as a rule they were kept up for from two to three weeks.

## RESULTS

The relevant bacteriologic and clinical data are summarized in table 1.

*Bacteriologic Findings Prior to Treatment*—As might be expected in cultures from chronically infected foci constantly subjected to contaminations, the bacteriologic results were not entirely satisfactory. The organisms listed in table 1 were the ones which predominated in the cultures. Most of those which could be isolated and maintained in pure culture were tested for sensitivity to streptomycin.

The organisms most frequently found before the streptomycin therapy was begun were strains of *Ps. aeruginosa* and of *P. vulgaris*, they were also the most resistant of the organisms encountered. The 12 strains of *Ps. aeruginosa* tested were sensitive to streptomycin in solutions of from 25 to 200 units per cubic centimeter, and the minimum inhibiting concentration for the 9 strains of *P. vulgaris* varied from 12.5 to 500 units per cubic centimeter. Most of the other organisms which grew in the cultures, including the strains of staphylococci and of various gram-negative bacilli, were more sensitive, they were sensitive to from 1.6 to 50 units of streptomycin per cubic centimeter, and most of them were completely inhibited by 12.5 units or less per cubic centimeter. One strain of diphtheroids required 5,000 units per cubic centimeter, but another was completely inhibited by 1.6 units per cubic centimeter.

*Clinical and Bacteriologic Results*—The clinical results in the individual ears are noted in table 1 and summarized in table 2. The drainage stopped in 15 of the 27 ears during the course of the local streptomycin treatment and did not recur during the period of follow-up observation, which continued for one to six months (1 patient, with both ears involved, was not followed after the treatment ended). There was temporary improvement in 7 ears. The drainage from these ears stopped for brief periods while they were under treatment but recurred either while streptomycin was still being given or shortly after it was discontinued. In 5 other ears there was little or no benefit from the local streptomycin therapy.

It is of interest that improvement occurred in each of the three groups. While the ears in group 1 were known to have had purulent discharge for only one to six

weeks, some of the ears listed as improved in group 2 and the 1 ear so listed in group 3 had not been free of drainage for many months or years

From the bacteriologic point of view, it is worth noting that in the ears from which the comparatively resistant organisms, namely, the *Pseudomonas* and *Proteus* strains, were obtained, good results were observed at least as often as in those from which other, more sensitive organisms were grown initially. The 15 ears which became and remained dry included 6 from which *Ps. aeruginosa* was obtained, 4 from which *P. vulgaris* was isolated, 1 in which both these organisms were present and 4 from which neither of them was grown in the pretreatment cultures.

*Appearance of Resistant Strains*—Cultures obtained while the patients were still receiving streptomycin therapy yielded 14 strains of organisms that were totally resistant. Two distinct species of resistant organisms were isolated from each of 2 ears. There were 4 ears, however, in which clinical improvement occurred, the discharge stopped and the ears remained dry in spite of the transient appearance of these resistant strains. Furthermore, 2 of the resistant strains did not correspond

TABLE 2—Summary of Clinical Results

Group	Number of Ears	Results			Number of Resistant Strains†
		Improvement *	Improvement and Relapse	No Improvement	
1	5	3	1	1	4
2	19	11	4	4	8
3	3	1	2	0	2
Total	27	15	7	5	14

\* The ear became and remained dry, cultures became sterile

† Resistant strains listed here were those not inhibited by 50,000 units of streptomycin per cubic centimeter of culture

In 4 ears (3, 15, 17 and 18) improvement occurred in spite of the transient appearance of resistant strains, in 1 case of bilateral involvement there was no follow up observation after treatment was stopped

Two resistant strains (1 each from ears 5 and 15) did not correspond with those obtained in pretreatment cultures

Two resistant strains of different organisms were obtained from each of 2 ears (ear 3, group 1, and ear 16, group 2)

with the organisms identified in the pretreatment cultures, they may, of course, have been present in small numbers and not been recognized. The strain of *P. vulgaris* in ear 4 retained the same degree of sensitivity to streptomycin throughout an initial course of treatment for nine days, but became totally resistant during a second course of topical treatment with streptomycin, which was begun eighteen days later. In a few ears some of the original strains persisted without demonstrable changes in sensitivity. In others new strains appeared during or immediately after the course of streptomycin therapy, these strains had and retained sensitivities to streptomycin within the usual range.

#### COMMENT

One of the main purposes of the present study was to determine whether the development of resistance to streptomycin, a major factor limiting the clinical effectiveness of the drug, could be avoided by the local use of the antibiotic in high concentrations. Evidence suggesting that this method might not be entirely successful is contained in the

results reported briefly by Hirshfeld and his co-workers<sup>8</sup> in the treatment of granulating surfaces with streptomycin applied as a wet dressing in concentrations of 200 to 500 units per cubic centimeter. They found "no significant change in the bacterial flora, most of the organisms which were present at the start of therapy still being present when it was discontinued. During the period of therapy, their resistance to streptomycin increased markedly." The concentrations of streptomycin may have been inadequate, in view of the sensitivity of some of the strains that may be encountered, but details were not given. The granulating areas, however, became red and healthy, and the grafts took well.

Maximum feasible concentrations, which may contain up to 100,000 units of streptomycin per cubic centimeter, were not used in the present study, though they might have given better results. The concentration of the solutions used, however, was twenty or more times as great, in each instance, as the minimum concentration required to inhibit the growth of the organism *in vitro*, as determined by the usual sensitivity tests. Totally resistant strains, nevertheless, appeared in an appreciable number of ears during treatment, indicating that the concentration of streptomycin to which the organisms are exposed is not the only, or the major, factor determining the appearance of resistant strains during the course of therapy.

Several factors may have interfered with the full effectiveness of streptomycin in the present cases, and thus may have contributed to the failures and, possibly, to the development of resistant strains. The activity of streptomycin is known to be greatly reduced in an acid medium and in the presence of excessive concentrations of bacteria,<sup>9</sup> factors which may both have been operative in the purulent otitic exudates. Furthermore, some of the organisms may have been present in situations inaccessible to the locally instilled streptomycin, and were thus protected from its action. This may explain the persistence of susceptible organisms in some of the ears. The most likely explanation, however, is that the resistant variants are present, usually in very small numbers, from the start, and that the exposure to the antibiotic serves to eliminate most of the sensitive bacteria, leaving the resistant ones to multiply. Such an explanation is consistent with the very rapid appearance of totally resistant strains in other circum-

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<sup>8</sup> Hirshfeld, J. W., Buggs, C. W., Pilling, M. A., Bronstein, B., and O'Donnell, C. H. Streptomycin in the Treatment of Surgical Infections. Report of Experiences with Its Use, *Arch. Surg.* **52**: 387-401 (April) 1946.

<sup>9</sup> Abraham, E. P., and Duthie, E. S. Effect of  $pH$  of the Medium on Activity of Streptomycin and Penicillin and Other Chemotherapeutic Substances, *Lancet* **1**: 455-459 (March 30) 1946.

stances, as, for example, during treatment with streptomycin of infections of the urinary tract<sup>10</sup>

While emphasis has been placed on the therapeutic failures, particularly from the bacteriologic point of view, the highly favorable results obtained in more than half the cases in this exploratory study should not be ignored. The clinical results in some of the cases in the present series are sufficiently impressive to warrant further investigation of local streptomycin therapy of chronic otitis with a view to developing modifications which would increase its effectiveness and reduce the frequency with which resistance strains appear. Several possibilities suggest themselves: (1) increase in the concentration of the streptomycin solutions and perhaps more frequent instillations, (2) lavage or irrigation with alkaline solutions prior to the instillations, (3) combinations of streptomycin with other chemotherapeutic or antibiotic agents, including penicillin, tyrothricin, sulfonamide drugs (the sodium salts in solution, in suitable concentration, might provide both a proper  $p_H$  and enhanced bacteriostatic activity) or some of the newer antibiotics or chemotherapeutic agents that may be ineffective by themselves, (4) methods to increase diffusion of the instilled materials through the middle ear cavity and (5) prolonged systemic therapy with streptomycin and the other antibacterial agents, in addition to topical applications. These methods, if used to supplement surgical procedures intended to eradicate foci by clearing away necrotic debris, should offer a better opportunity for the antibacterial agents to work and promote more rapid healing.

#### SUMMARY AND CONCLUSIONS

Bacteriologic and clinical observations were made in 27 ears with suppurative otitis, under treatment with local instillations of streptomycin solutions. Clinical improvement occurred in about half these ears. Drainage stopped during the treatment and did not recur during a follow-up period of from one to six months. Resistant strains of organisms previously susceptible to streptomycin appeared during the course of treatment in a large proportion of the cases in spite of the fact that the concentration of the streptomycin instilled was at least twenty times as great as the minimum concentration required to inhibit the organisms isolated before treatment was started. The highly favorable results in some of the cases in which the condition had failed to improve under other forms of therapy suggest that local streptomycin therapy may be useful in certain cases of suppurative otitis with organisms susceptible to streptomycin. Certain modifications which may enhance the efficacy of the therapy are suggested.

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10 Finland, M., Murray, R., Harris, H. W., Kilham, L., and Meads, M. Development of Streptomycin Resistance During Treatment. *JAMA* **132** 16-21 (Sept 7) 1946



## ANNOYING POSTOPERATIVE PROBLEMS IN OTORHINOLOGIC PLASTIC SURGERY

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**M**ANAGEMENT of the many annoying postoperative problems in otorhinologic plastic surgery demands a broad knowledge of general medicine, careful diagnostic methods and the exercise of mature surgical judgment. One must never lose sight of the fact that one's patient is an indivisible entity and that one is fundamentally a physician.

A careful medical history may elicit nothing regarding blood dyscrasia and nothing regarding acute or chronic disease, metabolic or otherwise, the complete blood count, serologic reactions, bleeding time, coagulation time and results of urinalysis may be within normal limits, yet one patient may show tremendous postoperative ecchymosis and swelling, whereas a second patient, subjected to the same careful technic, with sharp instruments and an experienced operator, and the same preoperative medication, will show negligible ecchymosis and edema. Unquestionably, as a surgeon perfects his technic and becomes more deliberate in each movement, the incidence of these annoying factors becomes less common, but they do occur.

To what variable factor can this situation be attributed? It is known that capillary permeability may vary in normal persons with normal blood pictures. Fairly reliable methods to demonstrate preoperatively the varied degrees of capillary permeability or weakness, and factors influencing them, have been reviewed in the literature.<sup>1</sup>

I have been using the Rumpel-Leede tourniquet test with the "flicking" test suggested by Jones and Tocantins.<sup>2</sup> Although tests for capillary fragility are not considered conclusive, I have found the following procedure of value in predicting the occurrence of ecchymosis after rhinoplasty.

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Read at the meeting of the American Otorhinologic Society for the Advancement of Plastic and Reconstruction Surgery, Atlantic City, N J, June 11, 1947

1 Goldman, L, and Correll, E M. Studies in Some Capillary Fragility States in Dermatology. Effect of Hesperidin and Hesperidin Methyl Chalcone, *J Invest Dermat.* 6 129 (April) 1945

2 Jones, H W, and Tocantins, L M. A Simple Test for Capillary Resistance. The "Flicking" Test, *Am J M Sc* 185 535 (April) 1933

The antecubital fossa is first inspected for areas of pigmentation which might later be mistaken for petechiae, and these are encircled with ink. A blood pressure cuff is applied in the usual manner above the elbow and inflated. Pressure is maintained slightly above diastolic for five minutes. At the end of four minutes, the distended veins in the antecubital fossa are flicked with the thumb and middle finger of the examiner. After removal of the cuff, an area of 7.5 by 5 cm. below that where the cuff was applied is inspected with an ordinary reading glass for petechiae.

The results in 50 patients examined in this manner previous to rhinoplasty may be summarized as follows. Patients with from no to 8 petechiae almost uniformly had very little postoperative ecchymosis about the eyes, and this disappeared completely in four to five days, patients with 8 to 20 petechiae had moderate amounts of postoperative ecchymosis, lasting from ten days to two weeks, and those with more than 20 petechiae had ecchymosis that dissected under the skin of the face to the mandible and sometimes into the skin of the neck and chest.

Lucia and Aggeler<sup>3</sup> described a familial type of simple, easy bruisability in women of fair complexion and thin-textured skin who had an unusual combination of physical sluggishness and mental hyper-irritability. Blood findings in these patients are within normal limits, but menstrual dysfunction and a low basal metabolic rate without evidence of thyroid insufficiency indicate a probable endocrine basis for this pseudopurpuric state. Three patients in this category were treated in the past six months, with small doses of thyroid and a vitamin K preparation. With the tourniquet test, they showed 12, 15 and 20 petechiae, respectively. Postoperative ecchymosis was slight and disappeared within seven to ten days in all of them.

All physicians have observed the increased nasal congestion in women just prior to and during the menstrual period. At this time, there is an increase in the sodium ion concentration of the blood stream, resulting in withholding of fluids in the body tissues and diminished urinary output. In an as yet unpublished report from the research laboratories of McKesson and Robbins, Inc., on their clinical experimentation with orally administered penicillin, Golden and his co-workers note that there is a diminished urinary output during the premenstrual period, but that there is also an increase in the total excretion of penicillin. The latter would suggest a greater capillary permeability or capillary weakness. The more frequent incidence of bleeding, ecchymosis and postoperative swelling occurring in patients operated on just before, or during, the first few days of the menstrual period

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<sup>3</sup> Lucia, S. P., and Aggeler, P. M. Simple Easy Bruisability. Pseudo-hemorrhagic Diathesis of Probable Endocrine Origin, *J. Clin. Endocrinol.* **2**: 457 (July) 1942.

may be explained on this basis. Numerous reports in the literature, by Rudel,<sup>4</sup> Brewer,<sup>5</sup> Walters<sup>6</sup> and others, corroborate this observation of increased capillary weakness just before and during menstruation, and of a rapid return to normal after the third or fourth day of menstruation. These facts suggest that rhinoplasty should not be performed just before or during the first two or three days of menstruation.

In 3 patients operated on during the menstrual period, considerable ecchymosis about the eyes resulted and lasted for three weeks. One patient had a small, permanent deposit of blood pigment in the lower eyelids. Tourniquet tests done on these patients many months after the operation, but on the first day of menstruation, showed 20, 12 and 24 petechiae, respectively. Another rhinoplasty was performed on a patient who was menstruating at the time of operation and who showed a normal blood picture and 14 petechiae in the test. Sodium chloride was withheld, and potassium chloride was administered for forty-eight hours before and after operation. Three milligrams of synkamin® (vitamin K preparation) was given intramuscularly the night before, and the dose was repeated on the morning of the operation. This patient had a minimal amount of ecchymosis, which disappeared entirely in ten days. To be sure, no definite conclusions can be drawn from isolated cases or from small series of cases, but reports of this type may provide a stimulus for further study along these lines.

Numerous remedies for capillary weakness have been recommended, tried and discarded. In a recent article on the relation of vitamin C to capillary fragility, Bicknell and Prescott stated that "there is a growing body of evidence negating any relationship between them."<sup>7</sup> It is believed, however, that vitamin C is a valuable adjunct in stimulating wound healing.

The work of Rusznyak, Szent-Gyorgyi and Bruckner<sup>8</sup> on vitamin P isolated from lemon juice, and later from lemon peel, has stimulated considerable scientific research on the use of this substance in reducing capillary weakness. The glowing reports in the literature by Griffith,

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4 Rudel, I. Capillary Resistance in Relation to the Menstrual Cycle in Women, *Klin Wchnschr* **20** 266 (March 15) 1941.

5 Brewer, J. I. Rhythmic Changes in Skin Capillaries and Their Relation to Menstruation, *Am J Obst & Gynec* **36** 597 (Oct.) 1938.

6 Walters, J. D. Capillary Fragility and Allied Tests, *Ohio State M J* **41** 632 (July) 1945.

7 Bicknell, F., and Prescott, F. *The Vitamins in Medicine*, ed 2, New York, Grune & Stratton, Inc., 1946.

8 Rusznyak, S., and Szent-Gyorgyi, A. Vitamin P Flavonols as Vitamins, *Nature*, London **138** 27 (July 4) 1936. Szent-Gyorgyi, A. *Deutsche med Wchnschr* **62** 1326, 1936. Bruckner, V., and Szent-Gyorgyi, A. Chemical Nature of Citrin, *Nature*, London **138** 1057 (Dec 19) 1936.

Couch and Lindauer<sup>9</sup>, Warter, Drezner and Horoschak,<sup>10</sup> and Shanno<sup>11</sup> and many others attest to the efficacy of this new active principle in controlling capillary weakness. Goldman and Correll,<sup>1</sup> in a paper on states of capillary fragility in dermatology, concluded that "transient and at times striking decreases in the positive capillary fragility test were noted occasionally immediately after the intravenous use of hesperidin methyl chalcone [a derivative of vitamin P]" Vitamin P should develop into a valuable aid in the control of ecchymosis following rhinoplasty.

As knowledge of vitamin P is the outgrowth of nutritional research, a few additional comments on nutrition should not be amiss. As an aftermath of World War II, because of the starvation and malnutrition in enemy prison camps, many nutritional problems have been investigated. Deficiency in one or more of the nutritional elements may delay convalescence and impair the powers of combating infection. The incidence of postoperative hypoproteinemia has received considerable attention. Scobey,<sup>12</sup> in an article on unrecognized "borderline" protein deficiency, stated that animal protein deficiency will not respond to vitamin or drug therapy, but will respond to the administration of protein hydrolysate. The use of partially hydrolyzed protein in concentrated form supplies all the essential amino acids necessary for rapid reparative processes.

Griesman<sup>13</sup> pointed out the danger of administering a solid diet to a patient after rhinoplasty, due to bone stresses and strains. I have recently used "essenamine" (a partially hydrolyzed protein) during the first week after rhinoplasty, with gratifying results both in comfort for the patient and in more rapid convalescence. For an occasional patient with a previous history of alcoholism, or for one suffering from postoperative psychic nausea and vomiting, daily doses of 1 ampule

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9 Griffith, J. Q., Jr., Couch, J. F., and Lindauer, M. A. The Effect of Rutin on Increased Capillary Fragility in Man, *Proc Soc Exper Biol & Med* **55** 228 (March) 1944. Griffith, J. Q., Jr., and Lindauer, M. A. Increased Capillary Fragility in Hypertension: Incidence, Complications and Treatment, *Am Heart J* **26** 758 (Dec) 1944.

10 Warter, P. J., Drezner, H. L., and Horoschak, S. Effect of Hesperidin and Ascorbic Acid on Capillary Fragility in Rheumatoid Arthritis, *J M Soc New Jersey* **43** 228 (June) 1946.

11 Shanno, R. L. Rutin: A New Drug for the Treatment of Increased Capillary Fragility, *Am J M Sc* **211** 539 (May) 1946.

12 Scobey, R. R. Protein Deficiency Conditions Observed in Private Practice, *New York State J Med* **46** 1691 (Aug 1) 1946.

13 Griesman, B. L. Structure of External Nose: Study from Point of View of Plastic Surgery, *Arch Otolaryng* **42** 117 (Aug) 1945.

of "solu B"<sup>14</sup> with vitamin C administered intravenously were of great benefit. This treatment was particularly helpful in the immediate post-traumatic period in cases of nasal, maxillary or zygomaticomalar fracture. On two occasions, however, during its prolonged use, a severe, generalized, exfoliative dermatitis developed, which proved most annoying for a few days, but cleared up when the medication was discontinued.

Kartavin,<sup>15</sup> in his work on the pathogenesis of postoperative hematomas, stated that blood coagulation was increased in the majority of a group of patients with psychologic shock. Postoperative coagulation of the blood was immediate in these patients. This observation, he stated, had been corroborated by others.

Last to be considered is the person with allergy. Since the introduction of the sulfonamide drugs and the antibiotics, the incidence of infection has subsided materially but the incidence of known allergy has mounted tremendously. This increment may be attributed to the more skilled methods of diagnosis of allergic conditions, but one feels that these drugs have probably been a factor in materially sensitizing the population. I have seen severe allergic reactions, delaying healing for many weeks, develop in patients with latent, unrecognized allergies who had been subjected to Killian's operation. Frequently, after rhinoplasty, the allergic patient will have edema of the nose and lower eyelids that persists for months. Occasionally a few weeks may intervene after normal regression of postoperative edema. Edema associated with pain and tenderness may then develop along the nasofacial sulcus, lower eyelids or septum, due to an activated allergy that before operation was latent and unrecognized. This persistent edema may occasionally interfere with normal shrinkage of the skin, interpose soft tissue between aligned bony structures, resulting in a wide bridge, or cause a permanent fulness behind the nasal tip.

A careful personal and family history should elicit confirmation, or at least suspicion, of an allergic condition, if one is present. When one is in doubt, examination of nasal smears for eosinophils, and frequently, but not invariably, observation of an increase in the number of eosinophils in the blood may clear up the picture. Complete testing, desensitization, when possible, and exclusion of the offending allergen should be carried out prior to any surgical procedure on the nose, and an elimination diet should be ordered. Whether the allergy is seasonal or perennial,

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<sup>14</sup> One ampule contains a mixture of thiamine hydrochloride, 10 mg, riboflavin, 10 mg, pyridoxine hydrochloride, 5 mg, calcium pantothenate, 50 mg, and nicotinamide, 250 mg, in powder form for injection after proper solution has been effected.

<sup>15</sup> Kartavin, V. A. Pathogenesis of Post-Operative Hematomas, *Vestnik khir* 61 19 (Jan) 1941.

operation should not be performed on the nose during any of the seasons when allergy is prevalent. As preliminary medication, one of the antihistamine drugs administered from twenty-four to forty-eight hours prior to operation and continued postoperatively should help greatly to avoid annoying sequelae. There is a divergence of opinion as to the effect of allergic states on capillary permeability. Castex and his co-workers<sup>16</sup> used the "suction cup method" to determine capillary permeability in an analysis of 100 cases of proved allergy, and reported no important changes with the state of allergy. In my own patients, using the tourniquet test and postoperative clinical observation, I found that capillary permeability was increased in the presence of allergic states. As early as 1914, Sir William Osler made the following comment in discussing purpura:

The anaphylactoid purpuras are so-called because they are characterized by one or more of the common changes observed in allergy like oedema, urticaria or angio-neurotic oedema. These conditions are not due to thrombocytopenia or other hematopoietic disturbances but to increased capillary permeability allowing the passage of plasma or blood into the tissues. The etiology is unknown but is sometimes found to be due to allergic sensitization in which cases the purpura and associated oedema are more properly termed allergic purpura.<sup>17</sup>

#### COMMENT

In describing some of the annoying postoperative problems encountered in nasal surgery, I do not pretend to give the solution. The observations presented are based on too few cases to be conclusive. If I have stimulated some interest in the solution of these problems and demonstrated that otorhinologic plastic surgery demands a broad knowledge of general medicine, careful diagnostic methods and the exercise of skilled, mature surgical judgment, I am satisfied.

1831 Barnum Avenue

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16 Castex, M. R., Ruiz Moreno, G., and Solari, M. A. Capillary Fragility in Allergic Patients, *An d Inst invest fis apl a la pat humana* 3: 147, 1941.

17 Osler, W. The Visceral Lesions of Purpura and Allied Conditions, *Brit M J* 1: 517, 1914.

# Clinical Notes; New Instruments and Technics

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## IMPROVED BRONCHOSCOPIC GLASSES

MILTON S. LLOYD, M.D.  
NEW YORK

A DESCRIPTION of these glasses first appeared in the ARCHIVES in August 1933<sup>1</sup>. An additional feature has since been added, which is of great value to the bronchoscopist.

The glasses consist of an ordinary frame into which lenses may be fitted. A hole is drilled through the bridge between the lens and the ear piece on each side and a bolt is inserted which serves as a center for a thin glass disk from 7.5 to 8 cm. in diameter. The disk may be rotated and provides protection for the eyes against material coughed out of the bronchoscope, as well as unlimited clear visual fields in case the glass is soiled.

If corrective lenses are necessary, particularly for presbyopia, the oculist's prescription may be divided in such a way as to give proper definition at the varying distances represented by the standard endoscopic tubes.

Part of the prescription is mounted in the frame as an ordinary lens. The remainder is divided as necessary for the individual case among two or more lenses which are mounted on the rotary disk.

In this way the bronchoscopist who requires exact vision at varying focal distances can adjust his prescription to suit the necessity of the moment by the simple maneuver of turning the rotary disk.

The accompanying figure illustrates the glasses. The adjustments in this case are for three focal distances, viz., 20 to 35 cm., 30 to 50 cm. and 45 to 65 cm.

667 Madison Avenue

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<sup>1</sup> Lloyd, M. S. Bronchoscopic or Surgical Glasses, Arch. Otolaryng. **18** 201 (Aug.) 1933.

948

## Medical Classics

aber, echt Irritationen oder voll in die Blase hinein  
 der Blase, und ist es daher richtiger, die Indur. durchzu-  
 zerren in der Vagina geknotet werden können.  
 Zu dem Ende wird der Laden an beiden Enden mit  
 verflochten oder schwach gebogenen Nadeln armirt, die Na-  
 deln von der Blase nach der Scheide zu durchgeste-  
 chen. Den L. mit der linken Hand aufzuziehen, be-  
 weitet die Blase, unter Kontrolle von der lin-  
 ken Hand, was, wie gesagt, nicht  
 zuweilen ist, nicht mit Seide oder Fil de France  
 sondern mit einem weichen, im Bereich des Stiches  
 Bl. fassen und mit  
 der linken Hand, die Lin-  
 den in die Blase einführen, die  
 sene Stellen  
 et, auf die  
 genau vor-  
 gelegt, so dass  
 die Indur. in der  
 Drainrohr  
 bis auf die  
 Öffnung der  
 Öffnungen  
 formgezogen  
 besonders dürt  
 Die Kranke wird nur  
 und in derselben schw-  
 T förmige Drainage  
 un-  
 gelagert, dass die vörl-  
 (Seitenbauchlage) in der  
 alle Stunde oder alle zwei Stun-  
 wird die Kranke von der rechten auf die linke und von  
 linken auf die rechte Seite umgelagert, um Druck am Trochanter  
 zu verhüten

Bronchoscopic glasses



# Progress in Otolaryngology

Summaries of the Bibliographic Material Available in the Field of Otolaryngology

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## TUMORS OF THE NOSE AND THROAT

GORDON B NEW, M D

AND

EDWARD L FOSS, M D

ROCHESTER, MINN

## TUMORS OF THE SALIVARY GLANDS

MUCOEPIDERMOID tumors of the salivary glands were studied recently by Stewart, Foote and Becker<sup>1</sup> Forty-five tumors of this type were noted in a series of 700 patients with major and minor tumors of the salivary gland, examined at Memorial Hospital for Cancer and Allied Diseases between 1928 and 1943 None of the mucoepidermoid tumors had the structural characteristics of a mixed tumor or of a tumor of the salivary glands

Quattlebaum, Dockerty and Mayo<sup>2</sup> observed that 10 per cent of a consecutive series of primary neoplasms of the parotid gland were adenocarcinomas of the cylindroma type Surgically, these adenocarcinomas generally appeared infiltrative rather than encapsulated, and application of the principle of wide local excision prevented recurrences in 5 of the 21 cases Pathologically, the appearance of dark-staining epithelial islands and strands, with central honeycombing in a hyaline stroma, was diagnostic Epithelial mucus was present in some of the tumors Infiltrative tendencies were pronounced, and there was a special predilection for invasion of nerve sheaths In 8 of the 20 cases in which follow-up data were available, the patients died of metastatic lesions within five years, in 5 of the 8 cases there was evidence of pulmonary involvement Two of the 20 patients died more than five years after operation, and 4 of the remaining 10 patients had "inoperable," recurrent tumors The authors conclude that solid tumors of

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From the Section on Laryngology, Oral and Plastic Surgery, the Mayo Clinic

1 Stewart, F W, Foote, F W, and Becker, W F Muco-Epidermoid Tumors of Salivary Glands, *Ann Surg* **122** 820-844 (Nov) 1945

2 Quattlebaum, F W, Dockerty, M B, and Mayo, C W Adenocarcinoma, Cylindroma Type, of the Parotid Gland A Clinical and Pathologic Study of Twenty-One Cases, *Surg, Gynec & Obst* **82** 342-347 (March) 1946

the parotid gland should be assumed to be malignant until proved otherwise, and they suggest that more radical surgical procedures will have to be used to obtain better results in the treatment of this form of neoplasm

Two cases of unusually large tumors of the neck are reported by Dixon and Benson <sup>3</sup> In the first case, the tumor was a hyperfunctioning, adenomatous goiter which weighed 1,075 Gm In the second case, the tumor was an adenocarcinoma of the parotid gland of the mixed type and weighing 2,100 Gm The authors stress the importance of adequate exposure in the surgical management of large cervical tumors In the removal of large goiters, the trachea should be located to facilitate tracheotomy, if this becomes necessary If part of the goiter is intrathoracic, the superior pole of the thyroid gland and the superior thyroid vessels should be isolated, doubly ligated and divided before one attempts to elevate the intrathoracic portion of the goiter The dead space left by removal of the goiter should be drained with a strip of finely woven gauze Mixed tumors of the parotid gland are almost invariably malignant histologically, but they rarely metastasize In the removal of large tumors of the parotid gland, avoidance of injury to the external carotid artery is of prime importance It is safer to ligate the common carotid artery than the internal carotid artery The facial nerve should be preserved if possible Postoperative radium therapy is advisable

Hellwig <sup>4</sup> reviews the data on 82 primary tumors of the salivary glands studied in the laboratory of St Francis Hospital, Wichita, Kan, in the past twenty years From embryologic, histologic and topographic studies, it is concluded that mixed tumors of the salivary glands are derived from misplaced elements of the notochord This view would explain not only the complex structure of mixed tumors but also the striking predilection of these tumors for the parotid glands

#### TUMORS OF THE NOSE AND ACCESSORY SINUSES

The genesis, diagnosis and treatment of typical and atypical cysts of the nasal floor are considered by Bernfeld <sup>5</sup> Eight cases of tumors of the nose or the accessory sinuses are reported Berger <sup>6</sup> reports

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3 Dixon, C F, and Benson, R E Surgical Management of Large Tumors of the Neck, *Am J Surg* **69** 384-390 (Sept) 1945

4 Hellwig, C A Mixed Tumors of the Salivary Glands, *Arch Path* **40** 1-10 (July) 1945

5 Bernfeld, K The Genesis of Typical and Atypical Cysts of the Nasal Floor, *J Laryng & Otol* **60** 145-159 (April) 1945

6 Berger, M D Neoplasms of Both Maxillary Sinuses, *Arch Otolaryng* **42** 397-403 (Nov-Dec) 1945

the case of a patient 62 years of age who had a malignant lesion in each maxillary sinus. The two lesions were distinct entities, the second developed while the patient was under observation for the first.

#### TUMORS OF THE LIPS AND MOUTH

Thoma and Blumenthal<sup>7</sup> report the occurrence of cysts in three generations of one family. In the first generation, the father had excellent teeth, but a cyst developed in the region of the lower left canine and was removed when he was 78 years of age, the mother had very poor teeth. In the second generation, there were two sons and three daughters. One son and 2 daughters had cysts, and the remaining son and daughter were heterozygotes, the dental characteristic was recessive and was transmitted to their children, in whom cysts developed. One son had 3 children, of whom 1 daughter had three cysts. One daughter had 2 children, 1 of whom had three cysts, the other child was not examined. Another daughter had 5 children, 2 of whom had cysts. The third daughter was operated on by Thoma thirteen years prior to the report for an infected dentigerous cyst connected with an unerupted left canine tooth in the upper jaw. She had eleven children, five boys and six girls. Ten of these children were examined, and cysts were found in 4. It is interesting to note that 3 of these children, 1 boy and 2 girls, had cysts similar to their mother's, all of which formed from the corresponding tooth on the other side, the right maxillary canine.

To prevent the recurrence of cysts involving the ramus of the mandible, Walker<sup>8</sup> has devised the following procedure. An incision is made from the molar region upward on the anterior border of the ramus. The tissues are widely reflected, and the cavity of the cyst is opened, after adequate removal of bone, this opening is enlarged and the lining of the cyst is removed. In the case of a dentigerous cyst, the offending tooth is extracted. The edges of the bone are trimmed. The final stage consists in inserting a stent mold carrying a Thiersch graft to cover the raw margins of the orifice. Adequate stabilization of the mold is achieved with silk sutures. After the mold has been removed, the opening is maintained by a plug attached to a denture.

Ivy and Curtis<sup>9</sup> state that the treatment for sublingual dermoid cysts is complete enucleation. They advise that if the mass is situated immediately beneath the mucous membrane it is possible that it can

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7 Thoma, K. H., and Blumenthal, F. R. Heredity and Cyst Formation, *Am J Orthodontics* **32** 273-281 (May) 1946.

8 Walker, D. G. Cysts Involving the Ramus of the Mandible, *Proc Roy Soc Med* **38** 451 (June) 1945.

9 Ivy, R. H., and Curtis, L. Two Cases of Sublingual Dermoid and a Case of Protrusion of Mandible, *Am J Orthodontics* **31** 666-675 (Nov) 1945.

be removed from within the mouth by a free incision and blunt dissection, it is, however, usually preferable to approach it from below. They describe the differential diagnosis of dermoid, ranula and thyroglossal cyst and report 2 cases of sublingual dermoid cyst.

Millhon and Parkhill<sup>10</sup> report an unusual case in which a myxomatous tumor, contiguous with an unerupted lower left third molar tooth, simulated a dentigerous cyst in roentgenograms. The patient, a man aged 38, had an encapsulated tumor lying distal to the tooth. The tumor was about 3 cm in diameter and, at the expense of the bone, had extended well into the ascending ramus.

Byars and Sarnat<sup>11</sup> state that the ameloblastoma is found most frequently near the angle of the mandible in young adults and describe their treatment. This tumor grows slowly, and unless it is completely removed it will continue to grow. The ameloblastoma seldom becomes truly malignant. Curettage, cauterization with drugs and irradiation are inadequate therapeutic measures. The lesion should be completely enucleated if it is unilocular, cauterized by heat if it is not too large and is multilocular or resected with a small amount of normal bone if it is extensive. These are the best methods of treatment, because they give the greatest assurance that no part of the tumor will be left. The surgical approach and procedure for various types of ameloblastomas and the necessary subsequent reconstructive surgery are considered.

Burford and Ackerman<sup>12</sup> present a second symposium on neoplastic lesions occurring about the oral cavity. Among the lesions they consider are plasma cell myeloma involving the mandible, angioendothelioma (Ewing) of the mandible, carcinoma of the buccal mucosa, extensive ameloblastoma of the jaw and carcinoma of the lower lip.

"Chutta cancer" of India is described by Khanolkar and Suryabai.<sup>13</sup> This is a carcinoma of the hard palate which clinicians regard as due to irradiation from the habitual smoking of a cigar called a chutta with its burning end inside the mouth. Hospital records indicate that leukoplakic lesions of the hard palate are frequently observed among chutta smokers. A carcinomatous process commences in an area of altered, opaque epithelium or, more frequently, starts as a small ulcer.

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10 Millhon, J. A., and Parkhill, E. M. A Myxomatous Tumor Simulating a Dentigerous Cyst, *J. Oral Surg.* **4** 129-132 (April) 1946.

11 Byars, L. T., and Sarnat, B. G. Surgery of Mandible Ameloblastoma, *Am. J. Orthodontics* **32** 34-46 (Jan) 1946.

12 Burford, W. N., and Ackerman, L. V. Symposium on Nineteen Cases of Benign and Malignant Lesions of the Oral Cavity, from the Ellis Fischel State Cancer Hospital, Columbia, Missouri, *Am. J. Orthodontics* **31** 551-555 (Sept) 1945.

13 Khanolkar, V. R., and Suryabai, B. Cancer in Relation to Usages Three New Types in India, *Arch. Path.* **40** 351-361 (Nov-Dec) 1945.

or a button-like nodule in a deeply congested, irritated patch of mucous membrane "Khaim cancer" also is considered. The inhabitants of Bihar, particularly men, are addicted to the use of khaim, a mixture of a powder of dried tobacco leaves and a small amount of lime. This is carefully rubbed in the palm of the left hand with the thumb of the right hand until the desired mixture is obtained. A pinch of the mixture is then deposited in the groove between the front teeth and the lower lip and left until it gradually becomes diluted with saliva and is swallowed. It is replaced with a fresh mixture at frequent intervals during the day. The resulting changes in the mucosa had not been carefully studied at the time of their report, but in a number of cases a superficial ulcerative process commences in a red, congested mucosa lining the gums and lip. The supervening growth is a squamous cell carcinoma, of the type usually seen in the buccal mucosa.

A series of 242 cases of carcinoma of the lip is reviewed by Charteris<sup>14</sup>. He states that, since the results of treatment in the majority of cases of carcinoma of the lip are known in about a year, his series includes cases in which operation was performed up to a year before the time of his report, in 1944.

Lawrence and Brezina<sup>15</sup> report a consecutive series of 145 cases of carcinoma of the oral cavity treated at the New Haven Hospital from Jan 1, 1931 to Dec 31, 1940. They state that the treatment of carcinoma of the mouth and pharynx is essentially a radiologic problem. The best results were attained after treatment of lesions of the buccal mucous membrane and the anterior portion of the tongue. In these groups, a five year survival rate of 23 per cent was obtained. The poorest result was found in the group with hypopharyngeal carcinoma, in which the survival rate was 8 per cent.

#### TUMORS OF THE NASOPHARYNX

Whiteleather<sup>16</sup> considers transitional epithelial cell carcinoma of the nasopharynx from the standpoints of historical background, pathology, clinical observations and therapy. He states that irradiation is the accepted method of treatment of this type of carcinoma and that at present it offers the most hope, whether it be of complete arrest or of palliation. Patients treated before cervical metastasis or intracranial extension has occurred can expect the best results.

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14 Charteris, A. A. Carcinoma of the Lip and Its Treatment by Radium (1928-1944), *Brit M J* **1** 719-721 (May 11) 1946.

15 Lawrence, E. A., and Brezina, P. S. Carcinoma of the Oral Cavity. A Ten Year Survey in a General Hospital, *J A M A* **128** 1012-1016 (Aug 4) 1945.

16 Whiteleather, J. E. Transitional Epithelial Cell Carcinoma of the Nasopharynx, *Am J Roentgenol* **54** 357-369 (Oct) 1945.

An exhaustive study of 454 cases of malignant lesions of the nasopharynx is presented by Godtfredsen,<sup>17</sup> who collected cases from the radiologic clinics of Denmark and Sweden. The diagnosis of the condition was verified histopathologically in the majority of cases. In the small number of cases in which microscopic data were wanting, clinical examinations indicated that the lesions obviously were malignant. Ophthalmoneurologic symptoms were present in 172, or 38.0 per cent, of the 454 cases. Nasopharyngeal tumors constituted about 0.8 per cent of the malignant tumors observed in the radiologic clinics. In a population of about 7,500,000 persons, the mortality rate due to all malignant lesions was about 0.005 per cent (about 1 in 200,000). Malignant lesions of the nasopharynx constituted about 0.4 per cent of all malignant lesions.

The symptoms, pathology, diagnosis and treatment of tumors of the nasopharynx are considered by Nielsen.<sup>18</sup> Of 10,721 malignant tumors in all sites, only 77 (0.75 per cent) were situated in the nasopharynx. The results of treatment are analyzed.

#### TUMORS OF THE LARYNX

Orton<sup>19</sup> reviews the literature on the larynx and on laryngeal surgery for 1945. Thirty-one articles are included in his bibliography.

From a consideration of the causes and prevention of edema of the larynx caused by radiotherapy, Jolles<sup>20</sup> concludes that as probably no single factor is ever responsible for edema, no single measure can be effective in combating the conditions. He recommends the adoption of some general type of therapy and describes measures for combating edema.

The physical requirements for a substitute voice are an air chamber and a glottis capable of vibrating. Gatewood<sup>21</sup> expresses the opinion that the esophageal orifice should lend itself well to the functions of the glottis. In some instances patients have considerable difficulty in aspirating air or in belching. In such cases, he recommends insertion

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17 Godtfredsen, E. Ophthalmologic and Neurologic Symptoms at Malignant Nasopharyngeal Tumors. A Clinical Study Comprising Four Hundred and Fifty-Four Cases, with Special Reference to Histopathology and the Possibility of Earlier Recognition, *Acta psychiat et neurol*, 1944, supp 34, pp 1-323.

18 Nielsen, J. Roentgen Treatment of Malignant Tumors of the Nasopharynx, *Acta radiol* 26 133-154, 1945.

19 Orton, H. B. A Review of the Available Literature on the Larynx and Laryngeal Surgery for 1945, *Laryngoscope* 56 61-84 (March) 1946.

20 Jolles, B. Causes and Prevention of Radiotherapeutic Oedema of Larynx, *Brit J Radiol* 18 278-283 (Sept) 1945.

21 Gatewood, E. T. A Simple and Practical Procedure for Developing Esophageal Voice in the Laryngectomized Patient, *Ann Otol, Rhin & Laryng* 54 322-327 (June) 1945.

of a small, semiflexible catheter through the nose and into the esophagus so that the distal end of the catheter rests in the upper third of the esophagus, and the catheter is then anchored to the tip of the nose. Air is furnished the esophagus by gentle pressure on a bulb attached to the proximal end of the catheter. With persistent effort, the patient is induced to relax after prolonged expiration and, at the same time, to compress the bulb rapidly but gently. After many repetitions of procedure sound is eventually attained.

Members of the Section of Laryngology of the Royal Society of Medicine discussed the treatment of carcinoma of the larynx at their meeting on Feb 2, 1945. Davis reviews 40 cases of early intrinsic carcinoma of the larynx in which laryngofissure was performed, and Colledge and Lederman state their views on the subject.<sup>22</sup>

Watson and Lambert<sup>23</sup> describe a method of treating carcinoma of the larynx in which the thyroid cartilage on the affected side is removed and roentgen radiation is applied directly to the exposed underlying surface. When applied in this way, the roentgen rays do not pass through the cartilage before reaching the lesion.

Laryngofissure is the treatment favored by Hare and Hoover whenever possible.<sup>24</sup> However, of a series of patients reviewed by these men, only 1 in 4 was seen early enough to be treated by laryngofissure. The authors state that they prefer irradiation to laryngectomy when laryngofissure is not advisable.

Eighty-eight cases of cancer of the larynx and pharynx, at the Charity Hospital of Louisiana during the four year period from 1939 to 1942, inclusive, are reviewed by Garcia, Schlosser and Marino.<sup>25</sup> In all the cases in this series the lesions were inoperable for either technical or clinical reasons. Irradiation was the only treatment employed. The three year survival rate was 24 per cent. For 47 cases in which the patients were observed for more than five years, the survival rate was 21 per cent.

Serial histologic study of specimens obtained by laryngofissure would prevent delay in the management of residual malignant lesions.

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<sup>22</sup> Davis, E. D. D., Colledge, L., and Lederman, M. Discussion on Treatment of Carcinoma of the Larynx, *J Laryng & Otol* **60** 218-231 (May) 1945.

<sup>23</sup> Watson, T. A., and Lambert, V. Results of Treatment of Carcinoma of the Larynx by X-Ray at Operation, *J Laryng & Otol* **60** 174-177 (April) 1945.

<sup>24</sup> Hare, H. F., and Hoover, W. B. The Treatment of Carcinoma of the Larynx, *North Carolina M J* **7** 93-98 (March) 1946.

<sup>25</sup> Garcia, M., Schlosser, J. V., and Marino, J. B. Cancer of the Larynx and of the Pharynx. Results of Radiation Therapy at Charity Hospital, New Orleans *M & S J* **98** 483-490 (May) 1946.

To demonstrate this, Snitman<sup>26</sup> cites the case of a 40 year old woman who had a laryngeal carcinoma removed by laryngofissure. The tumor appeared to have involved only the middle and anterior thirds of the left true cord, and to have been removed completely. Microscopic study, however, revealed incomplete removal of the lesion, which had involved the right true cord.

In cases of laryngeal carcinoma in which the tumor tissue approaches the anterior commissure, Patterson<sup>27</sup> advocates opening the larynx in the following manner. The thyroid cartilage, which may be ossified, is cut in the middle line in such a manner as to avoid injury to the underlying soft tissues. A parallel incision is then made about  $\frac{1}{4}$  inch (0.64 cm) from the central incision through the thyroid cartilage on the unaffected side of the larynx. The small linear portion of thyroid cartilage lying between the incisions is removed. An incision is then made in the middle line through the soft tissues with a diathermy needle. By slight retraction applied to the sides of the opening into the larynx, the growth can be inspected and its anterior limits ascertained.

Jackson and Norris<sup>28</sup> describe the various types of treatment which they use for carcinoma of the larynx, detailing their technics of laryngofissure and laryngectomy. In 148 cases in which laryngofissure was performed by these authors, there were no deaths. No deaths occurred in the last 70 cases in which they had performed laryngectomy at the time of their report. They review 150 cases of cancer of the larynx in which the patients were treated at Temple University Hospital by operation and irradiation during the period from 1930 to 1937. The five year survival rate in these cases was 64 per cent. In 59 cases in which laryngofissure was performed, the five year survival rate was 80 per cent.

#### TUMORS OF THE ESOPHAGUS

Boros<sup>29</sup> analyzes the various forms of treatment used in 332 cases of carcinoma of the esophagus occurring in the New York City Cancer Institute Hospital from 1922 to 1944. Results following use of roentgen rays and radium were for the most part unsatisfactory. Study showed no diminution in the size of the tumors, and the author expresses doubt that there has been any prolongation of life. Operation was performed

26 Snitman, M. F. Carcinoma of the Larynx. Significance of Histopathologic Study of Serial Sections, Preliminary Report, Arch Otolaryng **42** 178-185 (Sept) 1945.

27 Patterson, N. Treatment of Carcinoma of the Vocal Lip by Operation, J Laryng & Otol **59** 431-433 (Nov) 1944.

28 Jackson, C. L., and Norris, C. M. Surgical Treatment of Cancer of the Larynx, Laryngoscope **55** 196-215 (May) 1945.

29 Boros, E. Carcinoma of the Esophagus, Gastroenterology **5** 106-111 (Aug) 1945.



in 7 cases with a view to total extirpation of the malignant mass, but the lesions were found to be inoperable. Gastrostomy was performed in 168 cases, relief in swallowing and prolongation of life were experienced by some patients, but not by others. The mortality rate of the operation was high (25 per cent), and it is questionable how much benefit was obtained by the patients who survived. It appears that, in spite of all measures so far devised, carcinoma of the esophagus is practically always fatal and the results of operation are almost uniformly bad.

In 2, or 1.08 per cent, of 185 cases of esophageal diverticula in which operation was performed at the Lahey Clinic, carcinoma developed subsequently. This incidence of carcinoma in cases of diverticulum of the esophagus is much greater than the incidence of esophageal carcinoma in the general population. Hoover,<sup>30</sup> who has made this survey, expresses the opinion that the chronic irritation and inflammation associated with diverticula of considerable size must be considered a predisposing factor.

The Mayo Clinic

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30 Hoover, W. B. Carcinoma Associated with Esophageal Diverticulum. Report of a Case, *S. Clin. North America* 25:707-712 (June) 1945.

## Abstracts from Current Literature

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### Ear

HEARING IMPAIRMENT DUE TO CRANIOCEREBRAL TRAUMA W E GROVE, Ann Otol, Rhin & Laryng 56 264 (June) 1947

The function of hearing can be damaged by cranial trauma causing fractures, and an impairment of hearing may be found in cases in which there is no evidence of fracture. In experiments in which animals were subjected to trauma insufficient to produce fracture, hemorrhages were observed in the region of the round window and in the basal coil of the cochlea in slightly injured animals. When injury was more severe, the hemorrhages involved both the endolymph and the perilymph, extending sometimes almost to the helicotrema. In some of these animals the round window was torn and hemorrhages were found even in the ampullae and between the fibers of the acoustic nerve. The effect of such a head injury which does not cause fractures may well be designated as concussion of the internal ear, or commotio auris. By analogy and from reports of autopsies one can say that similar conditions may take place in the human ear. The blood which appears in the labyrinth may be absorbed and recovery take place with little or no permanent injury of hearing. On the other hand, the blood may organize and fibrous or fibro-osseous tissue develop, with eventual atrophy and degeneration of the neural elements. In the latter case permanent damage is shown by the loss of hearing.

Grove found among 832 patients who had undergone cranial trauma 228 with traumatically damaged hearing (27.5 per cent). There were 15 with total deafness of the affected ear, 185 with a pure perceptive or with a mixed type of involvement, 16 with pure conduction deafness and 12 in whom an aggravation of preexisting deafness occurred. The findings seemed to indicate that the likelihood of a hearing loss developing after a head injury is, in general, in direct proportion to the age of the patient—the older the patient the greater the likelihood of a loss of hearing. Fracture of the temporal bones does not necessarily mean that there will be an impairment of hearing, as in 10 of 25 cases of a longitudinal fracture and bleeding from the ears, there was no impairment of hearing. This was also true in 34 of 92 cases of unilateral fracture. Impairment of hearing was found in cases with no evidence of fracture.

M V MILLER, Philadelphia

CHANGING PICTURE OF MASTOIDITIS VON GEORG KEREKES, Pract oto-rhino-laryng 9 138, 1947

In an analysis of 521 cases of acute mastoiditis in which the mastoid process was operated on between 1930 and 1944, the symptom complex is evaluated. The cases were grouped by five year periods and all cases were discussed particularly in relation to the usual symptoms, the mild complications and the severe complications. The statistics show that the clinical picture of mastoiditis has undergone marked changes, and the symptoms have been so altered that each case must be carefully evaluated. The indications for operation have become extremely obscure, and in consequence extreme care must be exercised so that one is not confused by any masking of symptoms due to chemotherapy.

PERSKY, Philadelphia

THE ENDAURAL APPROACH TO THE TREATMENT OF CHRONIC OTITIS MEDIA  
 AUGUSTO LATORE AGUERO, *Rev de otorrinolaring* 7 57 (June) 1947

The author favors an endaural approach for mastoidectomy, and in a detailed article he describes the various technics and their modifications. He has used his own method on 38 patients. In most of these he employed Lempert's technic, but in order to avoid slow healing of the wound, he eliminates the first incision of Lempert's technic and thus preserves the skin of the posterior and superior walls of the external meatus. He describes the technic in detail, beginning with the various points of injection of the local anesthetic, following with his method of procedure and concluding with his postoperative results. He believes that the endaural approach has produced excellent results in all his cases. In 2 cases, in which the discharge from the ear continued, he found that the fault rested with an incomplete exenteration of all the infected cells, particularly those in Citelli's angle. The loss of hearing in his cases depends primarily on the preexisting pathologic process.

PERSKY, Philadelphia

### Larynx

TRACHEOTOMY IN BULBAR PARALYSIS ROBERT E PRIEST, LAWRENCE R BOIES  
 and NEILL F GOLTZ, *Ann Otol, Rhin & Laryng* 56 250 (June) 1947

In the epidemic of poliomyelitis in Minneapolis in 1946 there were 400 patients with the bulbar type of involvement among the 1,830 patients who contracted the disease. Of the 400, 75 were tracheotomized, and 29 of these survived. The authors analyze the observations on these patients and report more fully on 17 who "lived because of tracheotomy." They feel that the effect of anoxia on the central nervous system with damage to the respiratory and circulatory centers is an extremely important consideration and that tracheotomy (1) improves the chance of survival of properly selected "bulbar" patients if done before anoxia has produced significant damage in the central nervous system and (2) if used in conjunction with various means of producing artificial respiration will enable some critically ill patients to survive until natural recovery of damaged neural tissue can occur.

M V MILLER, Philadelphia

CONGENITAL CYSTS OF THE LARYNX PAUL H HOLINGER and ERIK P  
 STEINMANN, *Pract oto-rhino-laryng* 9 129, 1947

The authors believe that congenital cysts of the larynx are comparable to laryngoceles except that they differ in degree and embryologically can be considered as malformations formed during the development of Morgagni's ventricle.

PERSKY, Philadelphia

PENICILLIN IN TREATMENT OF LARYNGEAL DIPHTHERIA E VAN WYK and  
 A P VAN DER WEY, *Nederl tijdschr v geneesk* 90 1004 (Aug 17) 1946

The importance of general and local administration of penicillin in the treatment of diphtheria of the larynx and the lower respiratory passages is stressed. Of 7 patients with descending diphtheria of the larynx treated in this way, only 2 died. Every three hours 1 cc of isotonic solution of sodium chloride containing penicillin in a weak concentration (500 units per cubic centimeter) was injected into the trachea through a cannula.

VAN CREVELD, Amsterdam, the Netherlands [*Am J Dis Child*]

## Nose

THE THYROID AND THE NOSE ARTHUR W PROETZ, *Ann Otol, Rhin & Laryng* 56 328 (June) 1947

Proetz surveys 84 cases of nasal involvement associated with hypothyroidism and offers the following observations

1 Deficiency of "the thyroid hormone" (thyroxine) may result in changes of the nasal mucosa which can be recognized as such

2 These changes are of two types (a) red, dry, irritated, "chapped" or desquamative and (b) pale and boggy

3 Patients deficient in thyroxine may have an increased tendency to nasal infection and nasal allergy, and this tendency can be corrected by administration of thyroxin or thyroid U S P alone

4 Headache and nasal obstruction are prominent symptoms

5 The basal metabolic rate is helpful but not infallible in distinguishing cases suitable for treatment with thyroid or thyroxin U S P Five patients of the 37 who showed improvement had rates between minus 10 and minus 3, and 1 had a rate of plus 3

6 The basal metabolic rate is not a reliable prognostic index The 4 patients showing the greatest improvement had basal rates of minus 4, 9, 11 and 34 (later, minus 12) In all cases the response of the patient was considered more useful than the metabolic rate in determining the most effective dosage of the drug

M V MILLER, Philadelphia

ETHMOIDITIS IN CHILDREN JUAN CARLOS MUNYO, *Ann de oto-rhino-laring* (pt 2) 17 39, 1947

Munyo discusses the problem of ethmoiditis occurring in children He stresses the pathologic aspects, the incidence, some of the causative factors and the symptoms Treatment is almost always conservative Local treatment of the nose, parenteral administration of sulfonamide drugs, antibiotics and vaccines in the chronic cases are all included in his description of methods of combating this infection If treatment is instituted early, intensively and with the proper evaluation of impending complications, the latter do not occur PERSKY, Philadelphia

## Miscellaneous

AGRANULOCYTOSIS IN CHILDHOOD REPORT OF A CASE WITH SERIAL BONE MARROW STUDIES ERIKA BRUCK, *Am J Dis Child* 73 186 (Feb) 1947

Bruck reports recovery in a child of 2 years The otolaryngologic symptoms were "ear drums pink and dull, profuse mucoid discharge from the nose, lips cracked, covered with bloody crusts, mouth red, pharynx full of mucus, tonsils moderately enlarged Cause unknown"

The granulocytes in the blood varied between 0 and 84 per cubic millimeter for eleven days Six examinations of marrow taken from the sternum and the tibia were made At the height of the disease hypoplastic bone marrow with "lymphocytic reaction" was found Symptoms at onset were malaise and fever Necrotic lesions of the mucous membranes were present at a later stage A "fall of leucocytes and absence of granulocytes" also were observed later There were prostration lobar pneumonia of the left lung and a recurrent erythematous rash

Penicillin, blood transfusions, crude liver extract and small doses of pent nucleotide were administered. The observation is made that if the bone marrow in these cases is not completely destroyed at the first impact, recovery may take place, provided a concomitant infection does not overwhelm the body defenses.

Voorhees, New York

PREOPERATIVE AND POSTOPERATIVE MEDICAL THERAPEUTICS M S ERSNER and  
M ALEXANDER, Eye, Ear, Nose & Throat Monthly **26** 23 (Jan) 1947

In a series of 200 cases of rhinoplasty vitamin K and ascorbic acid (vitamin C) were used routinely. The incidence of primary bleeding is thereby reduced, and late secondary hemorrhage is not encountered. The incidence of ecchymosis and conjunctival hemorrhage is greatly minimized, and wound healing is aided.

When hypothyroidism has been established or is suspected, the administration of thyroid extract serves the purpose of aiding in the reduction of sodium chloride metabolism, thus hastening elimination of water and helping to reduce tissue edema.

Sulfadiazine was given routinely, and no case of slough or infection was encountered.

There were no toxic or deleterious effects of these drugs in any of these cases.

JENNES, Waterbury, Conn

REHABILITATION OF APHASICS IN AN ARMY HOSPITAL VIVIAN MOWAT SHEEHAN,  
J Speech Disorders **11** 149, 1946

The program of the rehabilitation of aphasic patients which is carried on at the Percy Jones General Hospital in Battle Creek, Mich., is described. Communication is damaged in the patients, and many simple problems are involved, which become gradually of great worry to these patients. They soon become aware that they can no longer do many simple things the doing of which they once took for granted. Usually their faults in reading and writing are blamed on paralysis affecting other functions. More serious difficulties arise from the reduction of the capacity for abstract thinking, from the defects of memory, from the shortening of the span of attention, from the lack of ability to concentrate and from the general impairment of intellectual functions. Tension, need for rest and sleep, anxieties and an almost complete lack of the sense of humor make the whole problem extremely difficult. Group work is stressed as valuable since, although this is less efficient, the patients inspire each other. Most aphasic persons are quite confused as to left and right. The vocabulary has to be built in an organized manner. Imitation is vitally important, but all possible approaches must be used. Metal letters arranged on a black table are valuable in teaching reading and spelling. The "sound mirror" is a useful bit of equipment. Basic English is helpful in aiding the patient to get adequate expression without having to learn too large a vocabulary. Writing, arithmetic, group singing, typing, mathematics and any other subject may be used to help the patient along. Speech and language training are coordinated with occupational therapy and physical therapy. The patient is constantly educated as to what aphasia is and what the prospects are for him. A bulletin describing aphasia, published by the University of Michigan Speech Clinic, is sent to the parents and all relatives of the patient. Some of the results are measurable, others simply show in the healthier and happier attitudes of those who live in the clinic.

PALMER, Wichita, Kan

INDICES OF ACHIEVEMENT IN VOICE INSTRUCTION FRANKLIN H. KNOWER and  
MARJORIE EMERSON, *J. Speech Disorders* **11** 159, 1946

Four groups of students were studied, numbering 17, 15 (the controls), 11 and 13, respectively. All were students of McKinley High School, Cedar Rapids, Iowa. Groups 1 and 2 were given a test of ability to use tonal symbols communicating emotional moods and meanings and were asked to read a short passage, the reading of which normally required 15 to 2 minutes, from Mark Twain's "The Oldest Inhabitant." Skilled college speakers received scores of 80 to 95 per cent intelligibility on these tests. Groups 3 and 4 were tested completely by recording of material. The conclusions were as follows: 1. The intelligibility test of tonal symbolism provides a practical test of achievement in the use of voice in speech instruction. 2. Recordings of a short sample of oral reading are useful in providing an index of achievement in voice usage. 3. Ratings of speech achievement of single trained but independent judges, although highly variable, are on the average higher than ratings of more generalized achievement in speech. 4. The rating-rater reliability of single judges was about the same as inter-rater reliability. 5. The use of paired comparisons will reveal improvement not recognized when a single standard of judging records of achievement is employed. 6. Voice improvement of far greater significance may be expected from a unit of concentrated instruction than from incidental voice instruction in a general speech unit. The students were not told that they were to be retested. Group 1 received instruction in emotional meanings and special individual instruction in the whole material. Group 2 (the controls) was given simple work in informal speech activities. All of groups 1, 2, 3 and 4 were retested six weeks later.

PALMER, Wichita, Kan

PARENTAL MALADJUSTMENT AND FUNCTIONAL ARTICULATORY DEFECTS IN  
CHILDREN KENNETH SCOTT WOOD, *J. Speech Disorders* **11** 255, 1946

Fifty pairs of parents were selected who had children with defects of the articulatory type not assignable to low mentality, loss of hearing or organic malformations. These parents were normal in intelligence, hearing and speech. The California test of personality and the Bernreuter personality inventory were given to all 100 parents, and the scores were compared statistically with the test norms. The speech-defective children were given the California test of personality and Pintner's aspects of personality test. Some of the children were given the Murray thematic apperception test. Two clinical groups were established on the basis of paired neurotic tendency ratings of the mothers, and a program of parental counseling was carried on in one group in addition to treatment of the children. The results were as follows: 1. Maternal scores on the Bernreuter inventory differed significantly from the test norms, showing that mothers of speech-defective children were more neurotic in tendency, more submissive and more self-conscious. The scores of fathers did not differ. 2. No correlation was found between the personality test scores of children and those of their parents. 3. Of the group of 50 speech-defective children, 72 per cent had at least one parent above the sixtieth percentile in neurotic tendency, and 64 per cent had at least one parent above the seventieth percentile. 4. Maternal scores on the California test of personality differed significantly from the test norms, indicating that mothers were lower in self-adjustment. Fathers rated lower than the test norms in self-adjustment. 5. Of the group of 50 speech-defective children, 86 per cent had one parent or parents who were below the thirty-fifth percentile in self-adjustment, and 64 per cent had one parent or parents who were below the thirty-fifth percentile in social adjustment. 6. Social standards of

mothers were found to be high in comparison with other adjustment scores 7 The scores of speech-defective children did not differ significantly from the test norms As a group they seemed better adjusted than either the mothers or the fathers 8 The results of the thematic apperception test administered to about 25 per cent showed a sense of frustration, withdrawing and lack of affection, anxiety-insecurity, lack of belongingness, achievement, aggressiveness, hostility and escape 9 The case histories, obtained for the most part from the mothers, revealed thirteen salient factors in home environment Most frequent factors were lack of recreational outlet, ignorance of child behavior problems, overly severe methods of discipline and defective home membership 10 When the mothers themselves were clinically treated for the alleviation of their own problems, their children improved more rapidly than did those of the control group 11 Functional articulatory defects of children are associated with maladjustment and undesirable traits on the part of the parents

PALMER, Wichita, Kan

SEX DIFFERENCES IN RELATION TO STUTTERING HILDRED SCHUELL, J Speech Disorders **11** 277, 1946

The author reviews the literature on sex differences, emphasizing the many differences which exist between the boy and the girl physically, mentally and emotionally, and develops the hypothesis that the boy, whose physical, social and language development proceeds at a slower rate than that of the girl, encounters more unequal competition and, consequently, undergoes more frustrations, particularly in relation to language situations, than the girl, that as a result he exhibits more insecurity, more hesitancy, more inhibitions in speech This hypothesis will have to be tested by more comprehensive studies than any so far made of stuttering The insecurities, anxieties and tensions in our culture appear to be increased by the contradictory attitudes prevalent toward the boy in that he is expected to exhibit independence, fearlessness and aggressiveness and at the same time be submissive, orderly, obedient and self controlled

PALMER, Wichita, Kan

SPEECH DISORDERS IN WORLD WAR II VIII STUTTERING WILLIAM G PEACHER and WILLIAM E HARRIS, J Speech Disorders **11** 303, 1946

The authors review such material as is available on stuttering as it was observed in the armed forces The Army was apparently justified in inducting stutterers The men observed have generally made a good adjustment and have served their country well in combat zones, communication zones and zone of interior assignments Many of them would have profited by speech training as demonstrated in this paper, if it had been practicable for the Army to provide such instruction Should the policy of universal military duty be inaugurated in this country, it is suggested that a more adequate standardized test service for speech defectives be organized by the Surgeon General and that stutterers and persons whose speech is otherwise defective who are capable of military service be sent to special centers where speech correction would be provided on a systematic basis

PALMER, Wichita, Kan

TESTING AND CORRECTING CLEFT PALATE SPEECH MARY WOOTTON MASLAND, J Speech Disorders **11** 309, 1946

The author reviews work with patients with cleft palate carried on at Children's Memorial Hospital of Montreal, Canada, for a year and a half 1 A word test, designed to discover those consonants during the articulation of which nasal escape

occurs, was given to 25 such patients and 10 normal adults 2 The nasal escape of air when the patient with cleft palate performed this test was demonstrated by the movement of a lever connected with the tambour of a pneumoscope 3 The efforts of the patient to reduce or eliminate the nasal escape of air were consistently more successful when visual indication of success or failure was provided by the pneumoscope 4 Simultaneous kymographic records of air pressure changes in the mouth and the nose, respectively, during articulation of the test words provided objective evidence which was used for analyzing the speech defects of the patient 5 Similar kymographic records were made at intervals during the course of speech training, and the number of consonants during the articulation of which nasal escape of air occurred was used as a measure of progress Four illustrative cases are presented

PALMER, Wichita, Kan

PARAGNOSIA AND PARAPHASIA MARY HUBER, J Speech Disorders **11** 321, 1946

Phonetic analysis of patients with paragnosia and paraphasia produces the following conclusions 1 It seems unlikely that for dysphasic persons as a group there are actually any particular vowel sounds that consistently present more difficulty than others, however, both pure vowels and diphthongs which represent names of letters of the alphabet, hence more meaningful symbols, may be more easily perceived and initiated by some 2 Vowel sounds presented in isolation cause less difficulty either in perception or in initiation than consonants 3 Four patients out of 6 experienced slightly less difficulty either in perception or in initiation of surd consonants than sonant consonants when these were presented in isolation 4 Whether one syllable words including only sonant consonants present more or less difficulty than vowels or consonants presented in isolation appears to depend on (a) whether the receptive dysphasia is largely a difficulty of perception or of comprehension and (b) the subject's attitude as set in the testing situation 5 For receptive dysphasic persons as a group, one and two syllable words including surd consonants represent greater difficulty either in perception or in initiation than one and two syllable words including only sonant consonants 6 Bilabial surd and sonant consonants appear to represent less difficulty either in perception or in initiation than other consonants 7 The phenomena of perseveration and association interference appear to complicate the problem of differentiation 8 Perseveration, or some disturbance related to it, appears to be one of the concomitant factors which combine to produce the symptoms of paragnosia and paraphasia

PALMER, Wichita, Kan

PUBLIC HEALTH ASPECTS OF RHEUMATIC FEVER ALBERT D KAISER, New York State J Med **47** 259 (Feb 1) 1947

Kaiser's paper, read at the annual meeting of the Medical Society of the State of New York on May 1, 1946, is of interest to otolaryngologists because of its implication of the group A hemolytic streptococcus Relative lack of immunity to this germ plus an acute infection of the respiratory tract and some evidence that "recurrences of rheumatic fever can be prevented by prolonged administration of small doses of sulfanilamide" are to be considered Further, "comparative clinical data on rheumatic fever and streptococcus infections run a close parallel" In World War II epidemics of rheumatic fever were closely associated with infections of the upper respiratory tract in the presence of hemolytic streptococci Kaiser states, guardedly, that "hemolytic streptococcus infections have something to do with rheumatic fever"



In the discussion, Dr J G Fred Hiss, of Syracuse, N Y, said that food has little to do with the causation. Neither has urban or suburban residence. He supported the opinion of Dr May Wilson that two factors are present: one within the patient (predisposition or lack of immunity) and infection, possibly streptococcic. Treatment directed against the streptococci was not emphasized—"rest is at present the best treatment." Education and vocational guidance are recommended, but it is not stated how these can prevent the ravages of a virulent, organ-destroying disease which leaves many cardiac cripples in its wake. To the ear, nose and throat specialist, it is hard to understand why internists are so loath to accept the findings of the bacteriologist.

VOORHEES, New York

STATUS THYMUS LYMPHATICUS. MARCOS COHN B, *Rev de otorrino-laring* 7 1 (March) 1947

Cohn presents a series of 3 patients who died suddenly during the course of surgical treatment. Tonsillectomy was to be performed on 2 of them, and the third was to have a nasopharyngeal fibrohemangioma removed. Each of the 3 patients died shortly after the administration of the local anesthetic and prior to the surgical operation. The anesthetic employed was 20 cc of 1 per cent procaine hydrochloride solution containing 10 drops of a 1:1,000 epinephrine hydrochloride solution.

In each of the 3 cases the postmortem examination revealed a persistent thymus, greatly hypertrophied lymphatic tissue in the Waldeyer tonsillar ring, and greatly hypertrophied lymph nodes and Peyer's patches in the intestinal tract.

Cohn attempts to establish a typical thymic syndrome. This is characterized by persistence of the thymus, generalized hypertrophy and hyperplasia of all the lymphatic tissue and poor development of the suprarenal cortex and the sexual glands. The skin is usually pale and smooth, with abundant fatty tissue; the hair is usually sparse; the musculature, flaccid, with a tendency to weakness. Status lymphaticus does not invariably depend on the presence of an enlarged thymus. On the other hand, the mere presence of an enlarged thymus does not necessarily indicate that the patient has status thymus lymphaticus. The cause of this condition is a moot question. It is claimed to be due either to an endocrine dysfunction or to a deficiency of the suprarenal cortex, which in turn causes hyperplasia of the thyroid gland and of the liver and a pancreatic hormonal deficiency. It is also an open question whether or not the status thymus lymphaticus constitution is a cause of sudden death, but since there are a number of these cases, the surgeon must realize that persons having this type of constitution present a greater surgical risk.

PERSKY, Philadelphia

# Society Transactions

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## CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

John R Lindsay, M D , *President*

Lawrence J Lawson, M D , *Secretary*

*Regular Monthly Meeting, Feb 2, 1948*

### Introduction DR FRANCIS L LEDERER

The governmental agencies concerned with veterans' hospitals are of particular interest to the physicians who practice the various specialties. Since the advent of the activities of the Deans' Committee, my colleagues and I have been engaged in organizing the services at the Veterans Administration Hospital, at Hines, Ill. The hospital has a total bed capacity of 1,795, and the Vaughn Unit a total bed capacity of 1,500. We have seven residents, one senior consultant and five attending otolaryngologists, and our patients occupy 52 beds for the general otolaryngologic service and 50 beds for treatment of tumors of the head and the neck. One attending otolaryngologist is employed on a full time and the others on a half time basis. The senior consultant examines patients especially selected for his observation and makes weekly grand ward rounds with the entire staff.

During the past year the department of otolaryngology of the hospital has given 2,563 patients what are known as "P-10" examinations to decide on admissibility. The patients examined, observed or treated by the attending staff totaled 7,632.

From the year 1938 up to and including 1946 the eye, ear, nose and throat services were combined. In 1947 the eye service was separated, in that year there were 300 eye and 1,558 ear, nose and throat procedures, the latter including every form of mastoidectomy, bronchoscopic and esophagoscopy procedures, nasal plastic surgery, submucous resection, tonsillectomy, removal of submaxillary glands, laryngofissure, laryngectomy, sinus operations, frontal bone operations and procedures dealing with all forms of cervical infection.

The resident staff consists of men who have completed their basic training in otolaryngology. This residency, therefore, constitutes their second year in the specialty. At this time the residency is limited to one year, but it is contemplated that in 1949 it will be extended to two years. The work of residents is supervised by attending men who are all members of the faculty of the University of Illinois. There are numerous conferences, otolaryngologic, general resident, tumor and departmental. In addition, these residents are included in the residency training program under the supervision of the University of Illinois. They participate actively in seminars at the university, the otolaryngologic forum at the Illinois Eye and Ear Infirmary, and in special lecture series arranged in the evening for their convenience.

### Intranasal Extension of Pituitary Tumors Presented by DR STANTON A FRIEDBERG

Certain intracranial tumors involving the region of the sella turcica are known to invade the sphenoid sinuses, the nasopharynx and the nasal passages by direct extension. The most common of these are pituitary adenoma and chordoma.

The Scientific program was presented by the University of Illinois representatives to the Veterans' Hospital, Hines, Ill.

The case histories of 3 patients were presented. In each instance the diagnosis of the specific intracranial lesion was made on microscopic examination of tissue ("polyps") removed from the nasal cavity. Two of the patients had typical malignant chromophobe adenoma of the pituitary gland. The third patient was found to have chordoma of the sphenoid-occipital type.

Headache, nasal obstruction and excessive postnasal secretion are probably the most common symptoms encountered by the otolaryngologist. Their significance becomes increasingly important with the realization that these same symptoms may be associated with the extracranial extension of sellar neoplasms.

Every patient known or suspected of having a lesion of the anterior or middle cranial fossa should have a careful nasopharyngeal examination, this study to encompass the utilization of all available diagnostic aids. Lateral views of the sphenoid sinuses and the sella turcica should be included in routine roentgenograms of the nasal accessory sinuses. The necessity for microscopic study of all nasal polyps is again emphasized.

#### DISCUSSION

DR THOMAS C. GALLOWAY: Why did you not operate in the second case transeptally by the method of Hirsch or by Clacari's technic?

DR JOHN R. LINDSAY: I recall 3 cases in which pituitary tumor extended downward into the nose. In the first one the tumor advanced in the septum halfway to the vestibule, in the second and third the nasopharynx was blocked. One patient, I believe, is living and well today, twelve years after roentgen ray therapy. Another was treated about eight years ago by means of radiation and was living several months ago. The third, for whom my associates and I recommended high voltage roentgen radiation but who was treated by implantation of radon, died of hemorrhage. In these 3 cases the tumor was diagnosed as chromophobic adenoma on biopsy.

DR STANTON A. FRIEDBERG: In reply to Dr. Galloway's question regarding an intranasal approach, there were two reasons why this was not done. In the first place, the patient was on the neurologic service. A second consideration concerned the areas involved and the mortality rate for the surgical treatment of extensive malignant pituitary adenoma, as pointed out by Jefferson. This author reported that there was 33 per cent operative mortality among patients with extrasellar tumor spread. This patient's lesion had extended into the left periorbital space as well as through the floor of the right sphenoid sinus.

Concerning Dr. Lindsay's comment: Irradiation is advocated by most writers for pituitary adenoma which has spread extracranially. One of our patients thus treated lived for four years after the diagnosis of intranasal extension was established. The outcome in the cases described by Dr. Lindsay would seem to bear out further the efficacy of this method.

The case history of the patient with the chordoma is interesting. It was possible to remove large masses of chordomatous tissue from the nasal cavity on four occasions over a period of eighteen months. This was done with coagulating diathermy because of the extreme vascularity of the tumor and resulted in marked relief from distressing nasal obstruction. After the last operation the tumor seemed to grow much more rapidly. Necropsy some months later showed the tumor extending along the entire basal plate of the skull and into all the paranasal sinuses.

## The Posterior Lateral Approach to the Larynx for Bilateral Recurrent Paralysis of the Vocal Cord Presented by DR ROBERT B LEWY

The greatest step forward in surgery designed to move one vocal cord laterally in order that the airway may be increased was accomplished not long ago by Dr Brien King. It was his concept that orthopedic principles be applied and that the arytenoid cartilage be pulled laterally by the action of the transplanted and affixed omohyoid muscle. However, the results of this technic were unsatisfactory in the hands of other surgeons. The principle remained. Thus it was that Dr Kelly modified this approach and found the arytenoid cartilage by making a window in the posterior third of the thyroid ala. He then transplanted the cartilage laterally. This has met with considerable success and is still the method of choice of most laryngeal surgeons. The operation still left a good deal to be desired in that there was a considerable percentage of failures, it was in a sense destructive as some cartilage had to be sacrificed, and, in addition, the operation was not anatomic. Instead of following tissue planes, direct access was accomplished by transecting the thyroarytenoid and cricoarytenoid lateralis muscles. This was not easy, and therefore attempts were made to find a more anatomic and less destructive approach.

The approach developed by Woodman (and herein reported) is a more posterior one. Incision is just anterior to the sternocleidomastoid muscle, dissection is then carried down plane by plane until the posterior margin of the thyroid cartilage is exposed. On the most posterior border of the ala an incision is made through the perichondrium, and this is elevated anteriorly and posteriorly. The articular facet (the main landmark) of the cricothyroid joint is found, and the cartilages are separated with an elevator. The incision is then carried through the posterior portion of the perichondrium, and the arytenoid structure is exposed. A slit is made in its perichondrium, and the arytenoid cartilage proper is exposed. This is then removed with a punch-biting forceps down to the vocal process. A stitch is placed which goes through the vocal process and part of the vocalis muscle. This is drawn around the inferior cornu of the thyroid cartilage and drawn up, thus pulling over the vocal process and the vocal cord in a manner similar to pulling a boat up to a dock. The stitch is then anchored in the sternocleidomastoid muscle. Closure is by layers, no 0 chromic catgut is used, the needle is a cutting one, half-inch, half-curved in shape.

### REPORT OF A CASE

A 33 year old white man was admitted to the Veterans Administration Hospital at Hines, Ill., on July 8, 1947. He complained that he had experienced a loss of 50 to 60 pounds (22.5 to 27 Kg) in one year, difficulty in breathing for six to nine months and twitching and cramps of the legs and the arms for a year. He had undergone thyroidectomy in March 1946, with severe respiratory difficulty requiring oxygen immediately following the operation. He was unable to speak above a whisper for several months postoperatively. He also had difficulty in swallowing. These symptoms grew progressively worse until he sought hospital care.

Physical examination gave negative results except for a thyroidectomy scar and slight exophthalmos. The blood calcium was 8.6 mg per hundred cubic centimeters. The red blood cell count was 2,900,000. The basal metabolic rate was minus 5. An electrocardiogram showed an increase of the Q-T interval. Roentgen studies of the tibia and the skull showed them to be normal. Laryngeal examination revealed bilateral paralysis of the vocal cords. Shortly afterward tracheotomy was done, and in the succeeding weeks the patient gained 20 pounds (9 Kg). On Septem-

ber 17 the King operation as modified by Woodman was performed, and the postoperative course was uneventful. During this time the blood calcium remained stabilized on a dosage of 10 Gm of calcium lactate daily. Since the operation he has gained more weight, stridor, dyspnea and dysphagia have disappeared. The airway by indirect view is now adequate, and he has returned to his previous occupation of automobile mechanic, which his preoperative condition had made impossible.

(Slides were shown demonstrating the technic of the operation.)

While this seems a logical approach to the solution of this problem and in this instance was successful, it was by no means easy. The process of getting down to the posterior ala of the thyroid cartilage is a painstaking one, and it was discovered that the long way around is the shortest way home. There is no doubt in my mind that dissection by layers is quicker and neater than the direct approach which was attempted.

One was reminded of the danger of working in this region when cardiac arrest developed in the patient. Fortunately, it proved temporary, but it indicated the advantage of injecting procaine hydrochloride locally over the region of the carotid sinus when this may be stretched or compressed. It was not easy to expose the arytenoid structure. Constant and marked tension from the edge of the thyroid cartilage upward was required, and the surgeon had to work under a canopy formed by the lateral wing of the thyroid cartilage. Placement of the needle was also difficult, correct placement determines the success or the failure of the procedure. It may prove of value to reverse the course of the needle so that none of the placement will be blind.

Despite these difficulties it is believed that the operation is an improvement over the King procedure. Further testing by a number of surgeons and comparing of results will be necessary to establish this point.

#### DISCUSSION

DR PAUL HOLINGER: The approach that has been described is excellent. A new suggestion made by King adds to opening of the airway. He puts a large knot on the suture and as he brings the suture through the arytenoid cartilage, the knot has a tendency to bring the arytenoid structure outward instead of tumbling it in. I believe this improves the airway by rotating the arytenoid cartilage into position. I think the suggestion of Galloway and Seed, namely, to remove a portion of the posterior border of the thyroid ala, is excellent, and I wonder if Dr. Galloway will comment on this technic.

DR MAURICE SNITMAN: At a meeting of this society several years ago, Dr. Galloway outlined the transthyroid approach. We have carried out this procedure in 3 cases and obtained satisfactory results in 2, where the arytenoid cartilage was displaced but not removed.

DR THOMAS C GALLOWAY: Dr. Seed and I saw no point in taking out the arytenoid cartilage. It is an advantage if you have a window in the thyroid cartilage, to have something to fill the space, and I wonder what the advantage is in removing it as Kelly and King have done. It serves as a guy to hold the vocal cord out. It is of course important that attachments of the cricoarytenoid articulation be completely freed.

DR JOHN R LINDSAY: Has any one had the experience of obtaining too wide an airway? I have had a case in which, following arytenoidectomy, the patient has more airway than she needs for comfortable respiration. She has air loss in speaking. The arytenoid cartilage is removed and the cord retracted laterally.

by means of a suture passed through it at the point at which it is attached to the vocal process

DR ROBERT B LEWY I do not know that I can give a truly competent answer to Dr Galloway as to why the arytenoid cartilage should be removed I think, however, that if it were not removed in using this technic one would fail in the desired result Without separation of the cricoarytenoid joint one would fail

As to the problem of the too wide airway, I was extremely cautious about that, I did my best to control the situation by laryngoscope in the patient's mouth and direct observation, I looked in when the knot was tied The usual failure occurs when the cord does not extend laterally far enough Then the surgeon may feel it would be desirable to operate on the opposite side as well This particular difficulty arises much more frequently than the problem of getting too wide an airway In the patient in the case reported, for a while after operation it seemed that the airway was not adequate It was not until five weeks later that I was satisfied that I had accomplished what I started out to do

### Clinically Malignant Tumors in Otolaryngology Presented by MAURICE F SNITMAN

"Malignant" is not a synonym for "cancerous" It refers to the harmful effects of any tumor, whether that tumor histologically is benign or malignant There is, fortunately, an increasing tendency to restrict the term "malignant" to new growths that are essentially deleterious to the host The important features of such growths are infiltration, local destructive properties, recurrence after incomplete removal, interference with function and general toxic action of the absorbed tumor products Tumors classified as benign possess almost all these features, and this fact is not sufficiently appreciated

Neoplasms such as nasopharyngeal fibroma, nasal papilloma and chondroma present problems of therapy whose magnitude is comparable to that of the problems of therapy of carcinoma and sarcoma With inadequate treatment such lesions will frequently prove fatal

A not uncommon lesion is the salivary gland tumor This designation does not fully imply the true malignant potentialities of the growth, and the need for radical therapy is not generally appreciated It has been my experience that clinically malignant tumors that do not bear the label of carcinoma or sarcoma do not receive the serious consideration they merit

I wish to present 3 cases that in some measure bear out these points

CASE 1—H R, a man aged 39, was first seen by an otolaryngologist in April 1943, because of nasal obstruction This was caused by a tumor in the floor of the left side of the nose Biopsy showed chondroma Local surgical resection was performed, which proved inadequate In December 1943 roentgen studies showed the hard palate to be eroded Between 1943 and the latter part of 1947 the patient underwent several surgical procedures, which again proved inadequate In October 1947 examination at the Research and Educational Hospitals of the University of Illinois disclosed extensive destruction of the left upper maxilla with involvement of the orbital floor and pterygopalatine fossa Radical resection was attempted, but the lesion was found to be too extensive for safe surgical intervention

CASE 2—G B, a man aged 65, was examined in August 1947 at the Veterans Administration Hospital at Hines, Ill, and found to have both sides of the nose filled with polypoid tissue, in the glabellar region there was a fistula about 2 by 3 cm in diameter, which led into the frontal sinus and was filled with polypoid

tissue similar to that in the nose. He had first experienced obstruction of the right side of his nose in 1934. The polyp was removed, and biopsy disclosed a pre-cancerous or carcinomatous degeneration. Radical antrotomy was performed on the right side, and subsequently he underwent antranasal polypectomy 24 times. In 1939 external frontal sinusotomy was performed, after healing, the area of the operative site broke down and produced a fistula. Because of the extension of the lesion, a radical exposure of the frontal area was then performed and the tumor destroyed by electrocoagulation. The cribriform area of both sides has been entirely destroyed, but the dural surface of the anterior fossa of the skull is well protected by scar tissue formation. Electrocoagulation of residual tumor has recently been performed, and on the last examination there appeared to be only small remnants of neoplastic tissue.

**CASE 3**—H. W., a man aged 54, complained, in February 1943, of nasal obstruction. Examination showed a tumor filling the right nasal cavity, biopsy revealed a salivary gland tumor of the basaloma type. Surgical removal was refused, and a course of roentgen ray therapy was given over the next few years, with resultant regression of the tumor. The patient was not seen thereafter until February 1947, at this time he complained of enlargement of the tip of the nose and shortness of breath associated with cough. Study of the chest showed both lung fields extensively involved by metastases.

From the foregoing cases it appears that most benign tumors of the head and the neck, although they do not bear the terms "carcinoma" and "sarcoma," merit efforts of therapy commensurate with those used in cases of carcinoma and sarcoma. Most histologically benign tumors, if inadequately treated, will, in many instances, prove fatal.

#### **The Otologic Effects of Streptomycin Therapy** Presented by DR. LINDEN J. WALLNER

Aural examinations were made of 93 patients receiving streptomycin at the Veterans Administration Hospital at Hines, Ill. They are divided into two groups according to dosage. Group 1 received 2 Gm. each twenty-four hours for four months. Group 2 received 1 Gm. a day. Audiograms and caloric tests were made before, during and after treatment.

One patient with anuria suffered almost total loss of hearing, no other patient was found to have any impairment of hearing from the drug.

Of the 53 patients in group 1, 42 noticed subjective symptoms of dizziness, staggering gait or visual disturbances, and 25 had objective evidence of depression or absence of vestibular function. Of the 40 in group 2, 18 complained of subjective symptoms, and 13 had depression or absence of caloric response. No return of function was noted later in those in whom responses were absent. They also continued to have subjective complaints, trouble on walking in the dark, and dizziness, though these symptoms became less bothersome. These patients were grateful for the improvement in their general condition and did not seem to feel the vestibular disturbances were too high a price to pay for it.

#### **DISCUSSION**

DR. SHERMAN SHAPIRO: I think one of the most interesting things about this paper is that there is shown for the first time the effect of something analogous to the experimental exclusion of both vestibular impulses in animals, practiced by McNally and other investigators. However, my idea is that in Dr. Wallner's patients this takes place at a higher level than the internal ear, somewhere in the

central vestibular area I would be interested to see how long these disturbances last If one judges from the effects in congenital deafness, there should be sufficient compensation in time for these people to function in a normal way One thing to know is whether or not there has been any change recently in the method of producing streptomycin It is not impossible that the toxic effects may be due to impurity in manufacture rather than in the drug itself

DR PAUL CAMPBELL I should like to mention two things The toxicity of streptomycin seems to be due to the ratio between intake and excretion In regard to Dr Wallner's case in which there was anuria, I think it has been proved that in four hours' time the streptomycin level can reach a point at which it can destroy the vestibular apparatus The internists do not seem to understand what a serious thing loss of the vestibular function is They seem to think it will soon be compensated for, however, this is not true I do not think such people could work on a roof or a scaffold, I certainly would not want them on my roof at my responsibility

DR JOHN R LINDSAY At the meeting of the eastern section of the American Laryngological, Rhinological and Otological Society a report was made that if the dosage of streptomycin was kept below 19 mg per kilogram of body weight per day, it would not be likely to cause vestibular signs Yet, according to Dr Wallner, some patients do get vestibular signs Dr Hawkins, of Merck & Company, pointed out that certain animals not only lose the vestibular response subsequent to streptomycin therapy but have loss of optokinetic nystagmus as well, which would indicate more widespread central damage

DR LINDEN WALLNER I cannot answer Dr Shapiro's question about possible impurities The patients in this report received the drug over an eighteen month period, so that a number of different batches must have been used

Subjective complaints were noted in about three weeks, but it was about two months before caloric responses were absent

**Osteomyelitis of the Frontal Bone Report of Case with Recovery** Presented by DR HARKISHEN SINGH

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## AMERICAN LARYNGOLOGICAL ASSOCIATION

Arthur W Proetz, M D, *President*

Louis H Clerf, *Secretary*

*Sixty-Ninth Annual Meeting, Hot Springs, Va., April 14-15, 1948*

Abstracted by Samuel Salinger, M D

**Tonsillectomy in the United States** Presented by DR L R BOIES

Tonsillectomy is still one of the most frequently performed operations in this country It therefore merits a discussion from the point of view of its effectiveness Boies states that the most common indications for the procedure are repeated attacks of acute infection, hypertrophy causing obstruction, and persisting infection He finds that persistent stumps are more common than is generally believed In a series of 430 patients he found 135 showing remnants of tonsils These are dangerous in most cases because they are embedded in scar tissue, which pre-



disposes to the retention of infection. Such stumps require radical removal, and they are not to be confused with enlarged lymphoid follicles. In his experience the lingual tonsil is not the common cause of morbidity. While its removal is generally indicated, one should not assume that this is easy. If removal is to be complete, one has to dissect up to the midline. Dr Boies makes it a routine to aspirate the tracheal accumulations via a Flagg laryngoscope after each operation. He believes this will do much to prevent postoperative pulmonary complications. As for the question of poliomyelitis, he is not convinced that the operation acts as a predisposing factor.

#### DISCUSSION

DR BURT R. SHURLY agreed that the relationship of tonsillectomy to poliomyelitis is much overdrawn. He had never seen a case of such a relationship in an experience of more than 20,000 tonsillectomies. Publicity has done much to instill fear of the operation in the minds of the laity, as a result of which many persons who would be greatly benefited by the operation are denied its benefits.

DR JOHN D. KERNAN considered the problem an exceedingly important one in view of the fact that around two million tonsillectomies are done in the United States every year. Many questions in this connection are still unanswered, particularly those dealing with the function of the tonsils and the effect of their removal on the general economy. The observation that lymphoid nodules appear throughout the pharynx after the operation leads one to speculate on the biochemistry involved and the possibility of a physiologic demand for this tissue. He expressed the belief that there are many good reasons for doing the operation, but he would like to have them supported by more scientific data than have as yet been available.

DR HENRY M. GOODYEAR added to the list of indications given by Dr Boies mouth breathing, attacks of otitis media and enlarged cervical glands. Also, he said that adenoidectomy should be considered at the same time, since the two are usually done in one sitting. The operation is not a simple one, and general practitioners should be discouraged from doing it. He is opposed to the procedure being done with the head in the extended position, because this interferes with proper visualization of the adenoidal region. It is important that a satisfactory palate retractor be employed so that the adenoids may be removed under direct inspection. As for recurrence of lymphoid tissue, he was convinced that if one administers iodine for a period of time, occasionally with thyroid extract, it will do much to retard this unpleasant phenomenon.

DR JAMES M. ROBB found, on dissecting a number of rats, that there was no lymphoid tissue in the rat's pharynx. Since this animal lives under most unhygienic surroundings, eating dirty food, it is difficult to understand the absence of this tissue if it has any value in protecting the organism against infection.

DR JOHN D. KERNAN stated that the pig lives under the most unhygienic conditions, certainly as bad as the rat's, and so far as he knows the animal does possess tonsil tissue.

DR L. R. BOIES, in closing, stated that it was his understanding that the rat, as well as all mammals, has tonsils.

#### Lermoyez' Syndrome—An Allergic Disease Presented by DR W. W. EAGLE

Eagle describes the Lermoyez syndrome as an allergic phenomenon similar to the Meniere symptom complex, except that the symptoms appear in the reverse order. Characteristic of the Lermoyez syndrome are the symptoms due to vaso-

spasm and the early appearance of allergic phenomena, such as urticaria, tinnitus and impairment of hearing, with vertigo as the last to be complained of. As a rule, the recovery is complete, and the deafness does not persist, as it does in Meniere's disease.

## DISCUSSION

DR FRANCIS L. WEILLE stated that at a recent staff meeting of the Massachusetts Eye, Ear and Throat Hospital the chief of the allergy service made the statement that he had never seen a case of vertigo in which allergy had played an important role.

DR MARVIN F. JONES referred to a paper he had published some years ago (Manifestations of Allergy of the Ear, *Ann Otol, Rhin & Laryng* 47 910, 1938), citing 8 cases in which the connection was definitely proved.

DR H. L. WILLIAMS recalled the fact that Meniere's original paper reported a series of cases in which deafness was the earliest symptom, often appearing years before the onset of vertigo. Concerning the role of histamine in Meniere's disease, the work of Farmer in New York and others has thoroughly discredited its importance. Neither does he believe that the histamine skin test is of any value so far as diagnosis is concerned.

In Dr Williams' clinic they see an average of 250 patients a year whose condition has been diagnosed as Meniere's disease or Meniere's syndrome, among whom he has noted only 1 that might possibly be considered as having the Lermoyez syndrome. This was a woman past the menopause, whose audiogram was typical of otosclerosis. Her attacks of vertigo, nystagmus and vomiting were relieved by stilbestrol.

Attention might be called to the fact that asthma, angioedema and such conditions are often not the result of an antigen-antibody reaction but are rather a manifestation of physical allergy. The work of Gottfried, Mueller and others leaves one in doubt as to whether these manifestations are truly those of allergy. It all depends on the definition the particular author wishes to employ.

DR W. W. EAGLE, in closing, admitted being confused by the history of Meniere's disease, especially in view of the recent interpretations of contemporary investigators. He felt that his presentation of the Lermoyez syndrome might help to separate the doubtful from the true Meniere's disease. He still was of the opinion that it is an allergic disease and he still would consider urticaria as an allergic phenomenon.

### The Cross-Sectional Area of the Lower Respiratory Tract at Different Levels and Its Possible Physiologic Significance. Presented by DR A. C. HILDING

Dr Hilding measured the cross section and the circumference of the secondary bronchi down to the bronchioles, from 0.8 to 1.75 mm in diameter, in five lungs. Contrary to the theoretic assumption that there is an enormous increase in air volume, the reconstructed measurements indicated an increase of volumetric capacity of only 50 to 100 per cent over that found in the trachea. Furthermore, it was found that the tracheobronchial tree down to the finest bronchioles offers no effective air-conditioning apparatus such as is found in the nose. However, the increase in area of ciliated mucosa down to the smallest bronchioles is something like twenty-five thousand times that of the upper respiratory area, which in itself is of vital importance in the filtration and separation of foreign material. Fifteen to forty thousand bronchioles lined with ciliated mucosa covered with a blanket of sticky mucus is an impressive figure.

## DISCUSSION

DR H I LILLIE raised the question as to how the air is conditioned in a patient breathing through a tracheal opening

DR THOMAS C GALLOWAY posed the problem of secretion accumulating in the small bronchioles and alveoli in the presence of respiratory paralysis. Aside from suction and postural drainage, what other mechanism would be available in ridding the passages of this material?

DR ARTHUR W PROETZ commented on the fundamental nature of this investigation and predicted that as its import is fully realized its value will be augmented in many practical ways

DR A C HILDING, in closing, said in reply to Dr Lillie that the trachea and primary bronchi are not protected, which accounts for the early accumulation of secretion and crusting. However, these are not the essential structures requiring protection. It is the alveoli that need efficient conditioning, because it is here that the vital function of oxygenation takes place. The thing that helps so much is the residual air already conditioned which acts as a cushion against the smaller amount of freshly inhaled air. The latter never goes directly into contact with the alveolar wall but reaches it only on being diffused through the already warmed and moistened residual air.

Replying to Dr Galloway, Dr Hilding stated that in respiratory paralysis the cilia themselves are not affected. They act independently of any nervous mechanism. They do function effectively in carrying the secretions up to the major bronchi. The failure to expel the accumulation is due to a mechanical impediment which is the result of the paralysis.

### Nerve Distribution of Clinical Significance in Laryngology Presented by

DR A C FURSTENBERG

Dr Furstenberg discussed the pathways involved in respiration, coughing, sneezing, hiccup, etc., and showed how these manifestations are affected in various pathologic states. There are two pathways by which respiration may be increased and only one by which it is lowered. The center for the latter is in the postorbital gyrus. Stimulation of this area, which occurs in complications of ethmoid and sphenoid sinusitis, causes a slowing of the respiratory rate which is observed before symptoms of intracranial pressure are manifest. Increased respiratory rate comes late from pressure and irritation in the preoptical brain areas. The cough and hiccup reflexes are similarly delineated. Emotional factors may initiate these reflexes which, when fully understood, will explain those cases in which the symptom persists despite absence of clinical findings. The author further described the incongruous symptom of nasal obstruction complained of by some patients after a well performed submucous resection of the septum. It is probably due to injury of the end organs of the fifth nerve in the mucosa, which affects the reflex arc. In these cases regeneration usually takes place with restoration of the normal sensation.

## DISCUSSION

DR NORTON CANFIELD cited 2 cases in which he hoped a solution to the dilemma might be forthcoming on the basis of Dr Furstenberg's studies. The problem had to do with 2 infants in whom tracheotomy had to be performed to relieve distress due to respiratory croup with laryngeal infection. Subsequent attempted removal of the tubes always was followed by spasm, which necessitated replacement a number of times. In 1 case it was six months before the child could do without the tube.

DR MARVIN F JONES was impressed with Dr Furstenberg's discussion of the nasal obstruction following resection of the septum, because it brought to mind his own experience of the same complaint in patients with atrophic rhinitis. He was convinced that the break in the reflex arc is due to a degenerative process following either trauma or disease. Disturbance of the reflex arc is only one of the manifestations of the degenerated end organ, one will also find sensation blunted and secretions abnormal. In other words, the membranes are nonfunctioning.

DR CHEVALIER L JACKSON mentioned another instance in which disturbance of a reflex arc was responsible for difficulty in respiration, namely, that of a post-laryngectomy patient who complained of difficulty in getting his breath despite an adequate stoma and absence of significant physical findings. Dr Jackson wondered whether the difficulty was to be explained on a psychosomatic basis or whether it was truly an interference with the normal reflex arc.

DR HAROLD I LILLIE inquired how one could explain the arrest of sneezing bouts by pressure on the upper lip. In connection with the nasal respiratory arc he had observed atrophy, loss of sensation and impaired nasal breathing following zinc ionization.

DR JAMES M ROBB commented on the association of tearing and sneezing. The reflex arc for tearing comes by way of the parasympathetic nerve which arises from the nervus intermedius and passes over the gasserian ganglion, and then over the second division of the fifth nerve and the zygomatic-temporal branch to the lacrimal gland. He asked whether Dr Furstenberg could connect up the fifth nerve with the reflex arc to explain the association of tearing with sneezing.

DR LOUIS H CLERF inquired about the reflex arc which would account for sneezing attacks on coming out of a dark room into the sunlight.

DR ARTHUR W PROETZ added an observation of a patient on whom sneezing could be induced by touching the hairline on the side of the head.

DR A C FURSTENBERG, in closing, believed that Dr Canfield's and Dr Jackson's cases could be explained on the basis of irritation of the tracheal mucous membrane, the reflex arc by way of the recurrent laryngeal nerve through fibers from the vagus nerve to the medulla and then down the spinal cord and to the so-called nucleus ambiguus which furnishes the motor impulses. Stimulation of the mucosa could certainly result in laryngeal spasm. Dr Jones's observations confirmed his own with regard to nasal obstruction following operation. However, the persistence of the complaint is dependent on the degree of atrophy which, of course, would vary between the extremes of a simple submucous and a well advanced atrophic rhinitis. Concerning Dr Lillie's inquiry, he believed that sneezing may be stopped by pressure on the upper lip because the pressure causes sufficient pain to stimulate the inspiratory center and halt the attack. Replying to Dr Robb and Dr Lillie, Dr Furstenberg showed a slide in which the connections between the fifth and seventh nerves were shown. Furthermore it showed how fibers of the seventh pass around the nucleus of the sixth nerve. It is possible that a synapse exists in this area.

#### **Etiology, Treatment and Prevention of Chronic Sinus Infection** Presented by DR SAMUEL J CROWE

A virus is the underlying cause of most of the conditions otologists treat in the upper air passages. As a result, the way is paved for pathogenic bacteria to enter into the sinuses, the lymph nodes, the ears, the tonsil crypts, etc. The cavities are shut off by swelling of the lining membranes, and this closure favors the development and propagation of the bacteria. The nasopharynx is frequently the

initial port of infection, particularly by way of the lymphatic elements. It is important, therefore, to see that this tissue is controlled, and up to the present time the best method of achieving control is by way of local irradiation.

In acute infection of the frontal sinus the author has had good results from external trephining through the floor of the sinus and instilling penicillin or tyrothricin. In a series of 102 patients 88 had to have this procedure, the remaining 18 recovering under antibiotic therapy.

(There was no discussion.)

### Associated Symptomatology of Diseases of the Epipharynx Presented by DR. WALTER H. THEOBALD

Thorough examination of the nasopharynx will often reveal the cause of a variety of symptoms not generally associated with disease of this region. Analysis of 150 cases showed that the most common symptoms reported were postnasal discharge and frequent colds. These were most commonly seen between the ages of 40 and 45. There were 16 cases of dry cough, 6 cases of bleeding, 9 cases of soreness and burning sensation and a number of cases of sore throat with adenitis. Otolgia was a frequent symptom in children. Local findings consisted of lymphoid masses, pharyngeal bursa, carcinoma and tuberculosis. Direct examination of the region with the nasopharyngoscope, or with the mirror, or through the Yankauer speculum or similar devices for exposing the epipharynx is important.

#### DISCUSSION

DR. FREDERICK T. HILL emphasized the value of direct inspection. He has found electrocoagulation useful in attacking lesions in this vicinity, using the Yankauer speculum as the indifferent electrode. In acute epipharyngeal infections it is well to bear in mind the possibility of diphtheria, particularly if the tonsils have been removed.

DR. THOMAS C. GALLOWAY recalled the experience of a former colleague, Dr. Profant, who had cured a man with a disabling arthritis by removing a pharyngeal bursa which had escaped the attention of fifteen otolaryngologists who had previously treated the man. Dr. Galloway is much interested in the question of the importance of lymphoid nodules, being of the impression that they do act as a nidus of infection, often an important one. He has had some success in eliminating these foci by using a punch forceps under direct inspection via a Love retractor. If islands of epithelium are left between the denuded areas, the raw spaces will soon be covered over and extensive scarring prevented. When a bursa is encountered, it can be cured only by operation. Irradiation may be used with caution. There are cases in which the lymphoid tissue reacts by increased growth rather than regression.

DR. SAMUEL SALINGER found it difficult to examine children directly with the pharyngoscope or palate retractor. He had had success in visualizing the region by anterior rhinoscopy after thorough shrinking of the turbinates. Having been trained to use the Kirstein headlight, he found no difficulty in focusing the light on the nasopharynx through the dilated nasal passages.

DR. W. H. THEOBALD, in closing, expressed his satisfaction in clearing up obscure cases of fever and bleeding which had baffled the internists, by tracing them to a chronic lesion in the epipharynx. Direct examination is the only way in which the entire field can be minutely examined and the furrows, crypts and hyperplasias located and evaluated.

## Complications Following Irradiation of the Thyroid Gland Presented by DR N M LUKENS

Serious damage of the larynx may ensue as a result of inexpert irradiation of the thyroid gland. Five cases are cited, 1 of which ended fatally. Cough, bloody expectoration, dyspnea and stenosis were the symptoms encountered, due to perichondritis of the laryngeal box. In some of the cases the disturbance lasted several years and necessitated numerous laryngoscopic examinations for removal of granulations, employment of dilators, etc.

### DISCUSSION

DR LOUIS H CLERF recalled having reported similar experiences twenty years ago. He had since then seen additional cases of this type in which the damage done to the overlying soft tissues of the neck resulted in telangiectasis, induration, atrophy, etc. In a patient who had received irradiation twelve years earlier for a benign lesion a postcricoid carcinoma developed. It is therefore possible to encounter a cancer due to the degenerative changes caused by injudicious irradiation.

Radiation therapy for benign lesions should be administered only by the most experienced radiologists who realize its limitations as well as its possible threat to normal tissues.

DR ARTHUR C JONES reported a case in which fatal ascending myelitis of the spinal cord followed extensive irradiation of the larynx of a girl of 13 for carcinoma. A pathologist who discussed this case when it was reported stated that he had seen 10 cases of ascending myelitis following high voltage irradiation of the cervical region.

DR SAMUEL SALINGER, reporting his experience with irradiation for carcinoma of the larynx several years ago, called attention to cases of necrosis and sloughing. More recently he reported a case in which radium applied to a child's neck for the cure of multiple papilloma of the larynx resulted in marked atrophy of the soft tissues and definite arrest of the development of the larynx. Since these cases were observed some years ago, he was under the impression that they were due to improper application of the therapy. He was therefore surprised to find that bad results are still being seen at a time when one is being led to believe that radiation therapy is safe. It is apparent that all patients who are being treated by irradiation of the neck should be followed closely for several years, not only by the roentgenologist but by the laryngologist. Certainly, consultation with the laryngologist in the first place should be a desideratum.

DR THOMAS C GALLOWAY inquired whether Dr Lukens had any information as to the value of irradiation in cases of carcinoma of the thyroid gland.

DR N M LUKENS, in closing, stated that he had not tried roentgen therapy for carcinoma of the thyroid gland but had been told by roentgenologists that it was indicated. As a matter of fact, he had seen several so-called cured cancers which still showed evidence of progression.

## Mucocele, Pyocele and Cystic Degenerative Lesions of the Mucous Membrane of the Frontal and Ethmoid Paranasal Sinuses Presented by DR HAROLD I LILLIE and DR C F LAKE

Analysis of 44 cases of mucocele, pyocele and cystic degeneration of the frontal and ethmoid sinuses reveals a history of previous infection or trauma, often with subsequent episodes of pain, nasal congestion, occasionally relieved by spontaneous discharge due to rupture, and intranasal drainage. Resorption of bone due to pressure of the growing mass leads to orbital invasion, with diplopia, or to exposure

of the dura Roentgenograms are helpful in diagnosis, although if the lesion is deep seated it may at times be difficult to differentiate it from a primary orbital tumor Also, when the mass completely fills the sinus, there will be difficulty in determining its origin The therapy is surgical, but the approach will depend on whether the cyst is seen before there are any external evidences of it, also on the status of the duct The latter is not to be disturbed if it is sufficiently patent In most cases the mass should be removed completely through an external approach

Lantern slides were presented showing various types of histologic structure, roentgenograms and cysts reconstructed after removal

#### DISCUSSION

DR HENRY M GOODYEAR was not in favor of removing the lining of the cyst in any case in which the cyst could be adequately and widely opened through an intranasal operation The lining in itself constitutes no danger Recurrence can follow only if the cyst becomes closed off again Complete resection through an external operation involves the possibility of stenosis of the nasofrontal duct from fibrosis Dr Lillie's series of 44 cases included 22 in which the patient had previously been operated on These cases are naturally difficult and do require radical surgical removal of the cyst

DR W L SIMPSON has had his best results in these cases following extensive resection through an external operation He removes all the ethmoid cells, cleans out the sphenoid sinus and widens the duct while leaving the middle turbinate bone in situ

DR. H I LILLIE, in closing, stated that he does not see the necessity for removing all the lining of the frontal sinus in the majority of cases, nor does he find it necessary to remove all the ethmoid cells Naturally, suppurative cysts fall into a different category The point is that the surgical procedure must be adapted to the individual case, and cannot in all cases be identical

#### Aliphatic Versus Aromatic Amines as Vasoconstrictors Presented by DR K K CHEN

Among the benzene-containing or aromatic amines, ephedrine still appears to be one of the best vasoconstrictors Its methyl group on a carbon atom from amino nitrogen serves as a protector against the action of amine oxidase This is responsible for the prolongation of action, and the effectiveness by mouth, of ephedrine The only other product which is comparable to ephedrine is "propadrine" Amphetamine is undesirable because of its stimulating action on the central nervous system Among the straight chain or aliphatic amines, compounds of 7 carbon atoms have optimal action Thus, "tuamine" and "fouramine" (2-amino-4-methylhexane sulfate) both have a high potency Here the methyl group on the atom is again necessary in order to preserve the prolongation of action A new compound, 2-methylamino-1-cyclopentylpropane, no 02040, which has a 5-membered ring but also belongs to the aliphatic series, has been shown to be more active than tuamine, fouramine and ephedrine It is effective by mouth It has one fortieth of the stimulating action of amphetamine on the central nervous system Emphasis is placed on oral administration of vasoconstrictors instead of local application This will rid therapeutics of those products which are not effective by mouth The synergism of vasoconstrictors and antihistamine drugs is also discussed

#### DISCUSSION

Dr Ernest M Seydell asked about the habit-forming effects of taking ephedrine by mouth in comparison with its local use

DR MARVIN F JONES inquired about dosage in the same connection

DR JOHN J SHEA was interested in the effect on the blood of long-continued administration of antihistamine drugs

DR BERNARD J MCMAHON inquired about the effect of giving barbiturates in conjunction with the oral administration of ephedrine

DR K K CHEN, in closing, stated that the habit formation of ephedrine was entirely psychologic because true addiction involves three things, namely physical dependence, in which the patient suffers on withdrawal of the drug, development of tolerance, in which the dose must be increased, and psychic habituation. Morphine is a good example. Ephedrine habituation is a psychic habit pattern due to the inferiority of the subject. No data have ever been presented to substantiate any theory that ephedrine is habit forming, and that applies even to the psychic aspect. There should be no difference between local and oral administration so far as habit formation is concerned. As far as dose is concerned, Dr Chen, in his early experiments was guided by the results of animal experiments and had himself taken as high as 150 mg, which is a huge dose compared with those presently used. About 25 mg three times daily is now considered adequate. Patients who react by becoming jittery should be instructed to lower the amount.

Concerning the antihistamine drugs, he had seen no demonstrable effects on the blood in all the experiments at his laboratory.

The combination of a barbiturate and ephedrine should act well when given at night, since it would protect the patient against insomnia, particularly if he were sensitive.

In response to a query from Dr Thomas C Galloway, Dr Chen stated that the oral administration of ephedrine may be followed by a late turgescence such as is seen some time after its local use.

Responding to another question, from Dr O E Van Alyea, concerning the effect of maphazoline ("privine"), Dr Chen stated that this drug is constructed entirely differently from the aromatic amines or the aliphatic amines, and that was why he did not mention it in the paper. As to the question "Is there any justification in the requirement of the Government that the label on nose drops of the vasoconstrictor types give warning of possible danger to persons suffering from heart disease, thyroid disorders, diabetes and hypertension?" Dr Chen said that as long as the manufacturer does not prove conclusively that the agent cannot possibly kill or injure, the notice on the label is required. The law is not perfect. It would perhaps be better if the product were put in the hands of physicians for a sufficient length of time for them to judge its possible side effects before granting clearance for public sale.

#### Laryngeal Tuberculosis Presented by DR E A LOOPER

Comparison of statistics as to the incidence of laryngeal tuberculosis in a series of 3,227 cases during the 1923 to 1928 period, and 5,238 cases during the 1938 to 1948 period, showed a reduction from 15.5 to 11 per cent. This has been due to earlier diagnosis and treatment, particularly to the increasingly popular pulmonary collapse. As a rule, diagnosis is much easier in sanatorium than in general office practice. Otolgia and early cough have been found to be significant. Dysphagia is seen mostly in patients with lesions of the epiglottis and the arytenoids. Dysphonia was seen but rarely. Seventy-six per cent of all patients were female, and most often between the ages of 20 and 40. In the early detection of laryngeal involvement routine laryngologic examinations are necessary in all cases of pulmonary tuberculosis, whether manifest or suspect. It is also important in all



cases to eliminate foci of infection in the nose and sinuses. The therapy comprises general treatment, vocal rest and local therapy. This can best be accomplished in an institution. Locally, cauterization has thus far given the best results. Streptomycin and sulfonamide drugs are helpful and show promise, but sufficient data are not yet at hand for an authoritative statement.

#### DISCUSSION

DR BURT K. SHURLY expressed his pleasure in witnessing the improving results of therapy over a period of many years. The incidence of the disease, in his experience, has gone down from 15 to 8 per cent. One hundred patients are now being treated with streptomycin in his institution, and the results obtained with 1 Gm daily doses have been encouraging. The drug is withdrawn at the first sign of labyrinthine disturbance.

DR LOUIS H. CLERF emphasized the importance of routine examination of the larynx in all cases of tuberculosis, even when the symptoms are receding. On the other hand, laryngologists need to be on the lookout for tuberculosis in cases in which carcinoma is suspected. In such cases the patient should be referred for a thorough examination of the chest, since frequently the pulmonary condition is quiescent. Also, there is need for revision of textbooks which still harp on the predilection of tuberculosis for the posterior half of the larynx, since Dr. Looper has shown that any part of the larynx may be affected.

DR FREDERICK A. FIGI showed 3 cases of tuberculosis of the larynx in which excellent results were obtained from daily intramuscular injection of 1 Gm of streptomycin and inhalation of from 0.5 to 1 Gm, combined in 1 case with penicillin.

DR HAROLD L. HICKEY has also noted a marked decrease in the incidence of laryngeal tuberculosis in his locality. He agreed that elimination of foci of infection in the mouth and upper air passages was essential, but called attention to the danger of surgical intervention in cases in which pulmonary tuberculosis was not arrested. He has seen the development of laryngeal tuberculosis closely follow tonsillectomy in such an instance.

Concerning vocal rest, it is imperative that at the same time general body rest be enforced. Even flexing of the pectoral muscles has been shown to affect the glottis.

DR FREDERICK T. HILL called attention to the importance of eliminating non-tuberculous lesions in tuberculous patients. A case in point was that of a young man with active tuberculosis, who complained of fulness in the throat, soreness and some dysphagia. Examination revealed a marked lingual thyroid, the removal of which was followed by relief of the local symptoms.

DR DANIEL S. CUNNING commented on the rarity of primary tuberculosis of the larynx, having recently observed a case in which roentgen examination, serologic tests and other procedures all failed to reveal any pulmonary involvement.

DR E. A. LOOPER, in closing, stated that he had never encountered a case of primary tuberculosis of the larynx.

#### Moniliasis of the Larynx Presented by DR. CLAUDE C. CODY

Monilia is classified between a true mold and a yeast. It is difficult to differentiate moniliasis from blastomycosis, and the two are very similar as to course. It is more important to differentiate moniliasis from carcinoma and tuberculosis of the larynx. Two cases are reported. One of the patients was a woman of 48 and the other a man of 54. The symptoms were pain, cough, dysphagia and hoarseness. Locally, papillomatous masses, fixation of a vocal cord and infiltration were

noted Also, roentgenograms of the chest showed diffuse moniliasis on both sides The organisms were recovered on slides and in culture Streptomycin and strong solution of iodine U S P cleared the lesions

## DISCUSSION

DR JOHN J SHEA reported 2 cases, in 1 of which the patient succumbed He agreed with Dr Cody that roentgenograms of the chest frequently reveal bilateral fungous invasion of the bronchi, as in his own cases, in 1 of which the pharynx was also involved Iodides, thymol, cod liver oil and sodium benzoate were given for more than a month before streptomycin was tried He emphasized the importance of the roentgenograms of the chest because it takes two to three weeks to obtain a diagnosis by culture

DR THOMAS C GALLOWAY asked whether *Moniliae* are primarily pathogenic or saprophytic, and whether their activity depends on some systemic condition

DR C C CODY, in closing, stated that the literature would indicate that many of the *Moniliae* do not seem to be pathogenic *Monilia albicans* in connection with some pyogenic type of infection becomes of itself an invading organism However, the situation with regard to moniliasis of the larynx is similar to that of otomycosis, since mycologists are still at odds over the question as to whether a pure fungus infection is pathogenic This is due to the fact that in both cases a pure infection is the exception rather than the rule

### Rhinoscleroma Apparently Cured with Streptomycin Presented by DR GORDON B NEW

Rhinoscleroma is on the increase in this country, as evidenced by a recent report in which 200 cases had been collected Dr New discussed the pathogenesis of the disease and described the typical lesions

His case was that of a woman of 32, born in Siberia, whose symptoms dated back fifteen years, having been diagnosed first in China When she was seen at the Mayo Clinic the nares were closed, the pharynx was scarred and the epiglottis and the larynx invaded, with some subglottic obstruction Tracheotomy was performed, and biopsy of a specimen revealed that the lesion was rhinoscleroma The bacteria were tested for streptomycin sensitivity The drug was then given at the rate of 250 mg every three hours, after seven days its administration was discontinued because of pains of the joints and malaise, but later was resumed After 53 Gm had been given, the airway was definitely widened After 95 Gm had been administered, the biopsy specimens were negative for the organisms Vestibular disturbance was noted, which diminished after four months The patient was followed for over a year, at which time the biopsy specimen still showed no bacilli of rhinoscleroma The contraction of the nares was corrected by a graft, with subsequent use of a stent Ten months later the airway was still good The tomographs in this case were instructive

## DISCUSSION

DR DANIEL S CUNNING recalled his report to this association last year of rhinoscleroma observed in two native-born brothers One has died in the meantime Since hearing of the efficacy of streptomycin he has employed it in the treatment of the other for nine months at the rate of 1.5 Gm every twenty-four hours However, aside from clearing up the secondary infection, the drug seemed to have had little influence on the lesions, which looked the same as they did before the administration of streptomycin was started

DR WILLIAMS reported on the use of streptomycin by inhalation as practiced by his associate, Dr K M Symonton, in cases of ozena. Culture showed *Klebsiella* associated with *Pseudomonas*. Although initial improvement was noted, the infections relapsed because the organisms had developed marked resistance to the drug. Dr Williams wondered whether the good results obtained by Dr New, contrasted with the poor results in the cases of ozena, were not due to the larger doses given parenterally, contrasted with the smaller doses administered by nebulization.

DR HENRY M GOODYEAR inquired of Dr Williams whether he had tried streptomycin hypodermically in any of his cases of ozena. Dr Williams replied he had not.

DR G B NEW, in closing, commented on the failure of the drug in Dr Cunningham's case, which was probably due to the fact that the germ was not streptomycin sensitive in that instance. It is important that sensitivity tests be conducted on cultures of material taken from the patient before it is decided to use the drug.

Dr New was acquainted with the work done by Dr Williams and Dr Symonton in the study of ozena. However, in his own case, knowing that he was dealing with a *Klebsiella* that was sensitive, he hit it hard and consistently, which may have accounted for the favorable outcome.

#### Cancer of the Larynx Presented by DR LE ROY A SCHALL

Dr Schall presented an analysis of 500 cases of carcinoma of the larynx seen at the Massachusetts Eye and Ear Infirmary. Of the patients, 418 were treated and traced, the remainder were studied for diagnosis only, or were refused treatment or were not followed. Ninety-two per cent were men at an average age of 60. Of the women the average age was 40. Pathologically, 35 of the cancers were rated grade 1, 210 grade 2 and 140 grade 3. As to therapy, 246 patients were given external application of roentgen rays, 14 treatment by radium and 158 were operated on. The percentage of cures following radiation therapy was fairly constant in three series of cases analyzed in the periods 1930 to 1935, 1935 to 1940 and 1941 to 1945, averaging 25. Enthusiasm for high voltage radiation accounts for the large number of patients thus treated. Dr Schall emphasized the following points in this connection: (1) Hopeless cases are not good for radiation therapy, (2) regression is not a cure, (3) the trial period of irradiation is a fallacy.

Cordal lesions are ideal for laryngofissure. Eleven lesions thus treated showed 27 per cent failures, 46 per cent were cured for five years or more and 27 per cent were healed but had been observed for less than five years. The operation is indicated in local lesions limited to the anterior or the middle third without fixation. All others should be dealt with by laryngectomy. Their five year cures in 63 cases numbered 30 per cent. Laryngectomy after irradiation was less successful, only 2 of 8 patients surviving for the five year period.

#### DISCUSSION

DR LOUIS H CLERF was impressed by the large number of patients who had received irradiation of their lesions. It has been his experience that the results from this form of therapy seem to be getting progressively worse. Since the radiologist claims his best results in the very group in which experience has proved that laryngofissure is eminently successful, Dr Clerf feels that their results have not supported their contention. As to the decision between thyrotomy and laryngectomy, one cannot be too careful. Unless the indication for thyrotomy is clear, one had better advise laryngectomy because it offers more to the patient than other plans of therapy. While some larynxes may be sacrificed, more patients will be

saved In this connection it is well to remember that one must be radical Conserving some of the structures attached to the larynx which may harbor cancer cells is a mistake It has been his practice in some cases to do a block dissection at the same sitting, and the results have justified this procedure

DR JOHN D KERNAN recalled his early experiences with laryngectomy as developed by Dr McKenty and is gratified with the progress achieved in the technic during the past thirty-five years Yet, despite the good results being obtained, one cannot forget that without a larynx the patient is in some respects a cripple This naturally accounts for the hedging that takes place when borderline lesions come under observation

The histologic picture is important and only those lesions of the lowest malignancy should be treated by a laryngofissure Cancers which have a similar appearance can turn out very differently The speaker can recall a patient whose cancer was so extensive that it was sprouting out around the tracheotomy tube To get about this growth it was necessary to remove the whole thyroid gland and do a complete dissection of the neck on both sides The patient is living twenty-five years after operation On the other hand, a patient, with a cancer with a gross appearance similar to this but with a more malignant histologic picture died one month after a similar operation with extensive recurrence

DR CHEVALIER L JACKSON agreed with Dr Schall as to the indications for thyrotomy If these are strictly adhered to, the five year cures will easily reach 85 to 90 per cent As to irradiation, he was not entirely clear about the indications Commenting on Dr Kernan's observations, he too had seen cases in which it was difficult to delineate the exact boundaries of a lesion When this difficulty is encountered during the performance of laryngofissure, one had better not carry it through There are cases in which the extension is submucous and cannot be detected with the naked eye

As for grading, his experience coincided with that of Dr Schall, namely, that grades 1 and 2 give the best results both on surgical treatment and on irradiation, whereas grades 3 and 4 are less favorable

DR H W D MCCART, acting as consulting laryngologist to the Radium Clinic in Toronto, Canada, has come to the conclusion that the early good results are not always lasting when the cases are observed over a period of years, and fall short of those obtained by surgical procedure Another important point is that if a patient with a lesion favorable for thyrotomy is treated by irradiation unsuccessfully, the patient must then undergo laryngectomy Thus a minor procedure is converted into a much more serious major operation Furthermore, the results in such cases are not nearly as good as those in which no radiation therapy had been given

DR EDWIN N BROYLES commented on the cases in which preliminary tracheotomy was necessary, it being his impression that in such cases the carcinoma has already extended beyond the intrinsic field

DR J M ROBISON recalled an article by Dr Rolls, of the Rockefeller Institute, dealing with the virus theory in connection with carcinoma He was impressed with the statement that tissues must be conditioned for cancer to occur This conditioning may occur as a result of irritation from smoking, drinking, infection or serologic or chemical alterations in the body If the tissue needs to be conditioned for the development of cancer, when the cells migrate into tissue that is not conditioned, they seem to have a proclivity for conditioning these new areas The reaction to therapy differs in these two instances Often the new area will clear up under irradiation, whereas the original nidus will resist this therapy and can be cured only by radical excision

DR L A SCHALL, in closing, stated that in his clinic radiologists are in complete harmony with the surgeons and defer to the latter on all controversial issues. Concerning grading, Dr Schall has little confidence in its value as indicating the type of therapy and can say only that the best results are obtained in cases of grades 1 and 2. As to indications for advising irradiation, Dr Schall would recommend it for the patients whose voice is absolutely essential to their vocation and whose cancerous growth is limited. Also, the patient must consent to be under constant observation for an indefinite period following the treatment. Too many tragedies have occurred in cases in which the patient wandered away from the clinic where he was treated.

#### **Carcinoma of the Trachea Presented by DR C W ENGLER**

Dr Engler reported 2 cases of carcinoma of the trachea. In one case the symptoms of cough and bloody expectoration led to fluoroscopic and bronchoscopic examinations, which revealed a mass in the trachea near the bifurcation. This mass cleared up completely after irradiation but recurred two years later, and another appeared below the glottis. Radiotherapy was again applied, but the result is not yet decisive.

In the second case the lesion was far advanced when first seen, causing so much obstruction as to necessitate an extended tracheotomy with an especially long tube to pass the lesion. Roentgen therapy was of little avail, and autopsy revealed that the carcinoma had extended into the esophagus and the peritracheal tissues.

Since Culp's review of the subject, in 1938, the author had been able to collect only 35 to 40 cases from the literature. He made a plea for more thorough roentgenologic study of suspected cases in addition to early bronchoscopic investigation. A number of five to ten year cures were cited. Also, Dr Engler discussed the histopathologic aspects of carcinoma of the trachea, including those of cylindroma, concerning which there is some difference of opinion.

#### **DISCUSSION**

DR EDWIN N BROYLES recalled having reported 2 cases of carcinoma of the trachea. One patient was kept going for eleven years by repeated fulguration of the involved region. Another seemed hopeless and was given roentgen therapy, which had little effect. Autopsy showed that the lesion, though extensive, was quite superficial and might have yielded to the therapy that was used in the first case. This emphasizes the importance of good roentgenologic studies to determine the depth of the invasion.

#### **Report of the Postoperative Course in Cases of Subperichondral Total Laryngectomy Presented by DR EDWIN N BROYLES and DR E M WALZL**

The subperichondral technic advised by Crowe and Broyles has been used in performing total laryngectomy on a number of carefully selected patients with intrinsic carcinoma of the larynx. The postoperative course in the last 28 consecutive cases is reviewed and the use of chemotherapy and some modifications of the technic of the operation are discussed. The modifications are (1) the use of mucous membrane from the dorsal surface of the epiglottis for obtaining a complete mucous membrane closure of the pharyngeal defect resulting from removal of the larynx, and (2) the local use of tyrothricin and sulfathiazole in the wound to prevent infection from contamination by secretions of the mouth. By the use of these modifications of technic, an almost completely uneventful postoperative course was

obtained in all cases. In the cases reviewed, there was no wound infection, no shock and no fistula formation. None of the patients required a feeding tube. The usual stay in the hospital was one to two weeks. The postoperative course of these patients is compared with that of a group in which no chemotherapy was used. It is concluded that when local chemotherapy is employed, the danger of wound infection from contamination by mouth secretions is unimportant, and that the operation as described reduces to a minimum postoperative complications and greatly shortens the recovery period.

## DISCUSSION

DR LOUIS H. CLERF said that the indications for this procedure must be well circumscribed because of the hazards of leaving the ribbon muscles and the perichondrium, in which undetected nests of cells might be hidden.

DR LEROY A. SCHALL pointed out that the utilization of the mucous membrane of the epiglottis was first advocated by Dr. Harry Barnes about fifteen years ago and had been employed by himself in 6 cases. However, in all 6 cases a recurrence developed. Consequently, Dr. Schall has given up this procedure.

DR JAMES M. ROBB asked the essayists to comment on the matter of recurrence.

DR E. M. WALZL stated that in the cases in which recurrence was noted it occurred in the region of the cricothyroid membrane and that really these cases were originally unsuited for the operation. Usually recurrence was late, up to five years, in probably between 65 and 70 per cent.

DR JACK McNAUGHTON suggested that the operation might well be indicated in the borderline case in which thyrotomy would be doubtful and yet laryngectomy too radical. He employed this procedure in 10 cases and found that since the weak point in the closure is where the pretracheal muscles fail to lap over, just above the stump of the trachea, the wound would heal better if the incision of the skin veered away from the midline at this junction, thus affording a good skin flap. He asked Dr. Walzl as to the suture material used in the tracheal mucosa.

DR E. M. WALZL, in closing, said he used triple 0 catgut. He agreed with Dr. Clerf that the indications for the operation were restricted and he certainly would not advise it if there were the least suggestion that the growth had extended into the preepiglottic space.

## Book Reviews

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**Detailed Atlas of the Head and Neck** By Raymond C. Truex, M.S., Ph.D. associate professor of anatomy, College of Physicians and Surgeons, Columbia University, and Carl E. Kellner, artist, department of anatomy, College of Physicians and Surgeons, Columbia University. Price, \$15. Pp 162, with 136 illustrations, mostly in color. Indexed. New York: Oxford University Press, 1948.

For many years "visual education" has been a trite phrase on the lips of many a teacher, but educators are just beginning in these post-War II days to grasp the full meaning of it. The modern lantern, colored slides, moving pictures, stereoscopic representations, the "off-set process" and other devices—all these have helped to make the hard road of the medical student easier to travel. As for anatomy, instructors used to rely entirely on the figures and texts of Gray, Cunningham and others, most of which were in black and white. For colored plates they were glad to have those of Spalteholz or some other "foreign" work. All of these helped pave the way for better visualization and comprehension, but students and teachers are no longer dependent on anybody or anything beyond the confines of the United States. Technology has reached almost the peak of perfection, and more and better teaching can be done here because there are now highly trained workers in all fields who are able and willing to teach.

This atlas of the anatomy of the head and neck is probably a precursor of what one may yet expect for the entire human body. The dissections offered by Dr. Truex are indeed "detailed" to the highest degree, and the artistic representations by Mr. Kellner are not only exceedingly exact but beautiful to look on. In Dr. Detwiler's phrase, one has here the work of two great students operating "in a state of true symbiosis" (Dr. Detwiler is professor and chief of the department of anatomy in the College of Physicians and Surgeons, New York).

The Introduction, by E. A. Boyden, of the medical school of the University of Minnesota, states that the originality displayed in the sequence and the character of the dissections used in presenting a series, which can be analyzed and easily remembered, is significant. He cites the dissection of the anterior triangle of the neck in figure 12 as "the thyroidectomy approach." This enables one to follow the visceral and vascular columns, and associated nerves, into the thorax. Beginning with figures 17 and working through to figure 26, the student has before him the parotid space (site of myxoma), leading to the retromandibular area, then the pterygoid muscles and the structures flowing through them like an archway, then the parapharyngeal area, not well understood by many undergraduate students, and finally, under the mandible, the relations of hyoglossus muscles so important in operating on the tongue. For many otorhinolaryngologists, the middle fossa of the skull and its contents, especially the temporal bone, are not readily understood. Here the anatomy is made plain by figure 54, which shows the middle fossa and the petrous bone, which when sectioned horizontally discloses the labyrinth, the tympanic cavity and the internal and middle ear in juxtaposition. In the view taken from above one has the left cavernous sinus and the tympanic cavity, the right infratemporal fossa and the right bony labyrinth. The courses of the auditory, facial and chorda tympani nerves are well shown in their true relationship to other structures. Noteworthy

too is the splendid exposure of the orbit with the eyeball in situ. Every muscle and nerve is seen in its anatomic position, and all blood vessels are fully presented. Figure 65 and following illustrations show the anatomy of the pharynx and larynx seen anteriorly and posteriorly, superiorly and laterally. The neuroanatomy is especially well illustrated. In fact, the neurologist can profit greatly by the enormously detailed exposure of all nerves in the areas mentioned. The anatomy of the cerebrum and the cerebellum is well described in text and figures. Sections of the gross anatomy of both head and neck are viewed vertically and horizontally in series, so that a complete understanding of all anatomic relationships can be easily made out. Here is a work which holds an exceedingly high standard before any subsequent attempts to delineate the anatomy of one of the most difficult regions of the human body. All praise to these indefatigable workers who have contributed this magnum opus.

**Ophthalmology of the War Years** Edited by Meyer Wiener, M.D. Volume 2 (1944-June 1946) Price \$16 Chicago The Year Book Publishers, Inc., 1948

As did the first volume, which covered the period 1940 to 1943, this second volume reviews the articles and case reports in the field of ophthalmology for the benefit of those who were on war service at the time the material was published. Thirty-three subjects, from anatomy and embryology to diseases of the uveal tract, are presented by an equal number of associate editors. A chapter dealing with the effects of agents of chemical warfare on the eye, which did not appear in the first volume, is now introduced.

While the book is intended primarily for the ophthalmologist, there are two chapters of great interest for the otolaryngologist "Orbit, Eyeball and Sinuses," and "Relationship of the Eye to the Ear, Nose and Throat." Here one finds it reported that most cases labeled orbital cellulitis are in reality acute frontal sinusitis or acute ethmoiditis with orbital edema, that in iridocyclitis of obscure origin the focus of infection is more often in the tonsils than in the sinuses, that in 50 per cent of a series of 75 patients with associated nasal and conjunctival inflammation cultures from both sites revealed organisms similar in type and toxicity.

The relationship of ipsilateral glaucoma and sinus or nasal disease, discussed in the first volume, is treated further in the second. The theory is suggested that the connecting link is reflex irritation of the vasomotor apparatus controlling the circulation of the orbit. There has been lowering of intraocular tension after cocainization of the region of the sphenopalatine ganglion. Others report prompt relief of pain and rapid healing of corneal ulcers after such cocainization and attribute this result to a block of vasomotor spasm of the circumcorneal vessels. Retrobulbar neuritis also seemed benefited by this procedure.

The approach to current medical literature utilized in this volume and in its predecessor makes for stimulating reading. In many cases greater detail would be desirable, but a complete bibliography is provided at the end of each chapter for those who seek further development of any of the topics.

**The Lung** By William Snow Miller, late emeritus professor of anatomy University of Wisconsin. Second edition. Pp 222, with 168 illustrations, some in color. Price, \$7.50 Springfield, Ill. Charles C. Thomas, Publisher, 1948.

As the author states, there is no great difference between this and the first edition, which found a place of value in medical literature. There are some



additional illustrations in chapters 4, 6 and 9 Professor Larsell has studied the nerves of the visceral pleura, the results of which are set down in chapter 9 Particular emphasis is laid on the structure of the lung, for on this basis its diseases may be studied, and rational treatment instituted The author again states that the lung is lined (the alveoli) by epithelium, although some other authorities disagree A bibliography containing some 255 references is noteworthy, taken from Latin, German, French and Italian literature as well as English and American The direct tube specialist will be interested particularly in the matter relating to the lymphatic channels and lymph nodes of the trachea and the bronchi Of the tubuloacinous type, they are placed in the submucosa and are more abundant in the anterior wall of the trachea than in the lateral wall This may explain the distressing "itching and scratching" of tracheitis so often felt at the episternal notch and associated with a dry, hard, nonproductive cough Bacteria which invade this tissue have an almost impregnable stronghold, and, therefore, tracheitis may go on and on for weeks! In chapter 10 the author describes five "keypoints" where certain structures are constantly found They have to do with radicles of the pulmonary vein, the distal end of a ductus alveolaris and "the place where a bronchus or a bronchiolus divides" There is also a "transitional zone" in which tubercles are most likely to develop "Possibly a retardation of the circulatory force at this point may be a determining factor"

## News and Comment

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### GEORGIA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

The annual meeting will be held at the General Oglethorpe Hotel, in Savannah, March 4 to 5, 1949

The distinguished lecturers and their tentative subjects are Dr Paul A Chandler, of Boston, "Glaucoma Management", Dr Jack S Guyton, of Baltimore, "Cataract Management", Dr Oscar C E Hansen-Pruss, of Durham, N C, "Allergy of the Upper Respiratory Tract", Dr Marvin F Jones, of New York, "Management of Ear Problems in Children and an Otological Survey", Dr Ralph O Rychener, of Memphis, Tenn, "External Eye Diseases and Dacryocystitis", Dr Fletcher D Woodward, of Charlottesville, Va, "Problems in Laryngology"

# Directory of Otolaryngologic Societies\*

## INTERNATIONAL

### FOURTH INTERNATIONAL CONGRESS OF OTOLARYNGOLOGY

President Dr V E Negus, London, England  
General Secretaries Dr F C W Capps and Dr W A Mill, 45 Lincoln's Inn  
Fields, London, W C 2  
Place London Time July 18-23, 1949

### SECOND PAN-AMERICAN CONGRESS OF OTO-RHINO-LARYNGOLOGY AND BRONCHESOPHAGOLOGY

President Prof Justo Alonso  
Secretary Dr Chevalier L Jackson, 255 S 17th St, Philadelphia 3  
Place Montevideo Time January 1950

## NATIONAL

### AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON LARYNGOLOGY, OTOTOLOGY AND RHINOLOGY

Chairman Henry B Orton, 224 Delavan Ave, Newark, N J  
Secretary Dr J Milton Robb, 1553 Woodward Ave, Detroit, Mich  
Place Atlantic City, N J Time June 6-10, 1949

### AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Conrad Berens, 35 E 70th St, New York  
President-Elect Dr J Mackenzie Brown, Box 584, South Laguna, Calif  
Executive Secretary-Treasurer Dr William L Benedict, 100-1st Ave Bldg,  
Rochester, Minn

### AMERICAN BRONCHO-ESOPHAGOLOGICAL ASSOCIATION

President Dr Paul Holinger, 700 N Michigan Ave, Chicago 11  
Secretary Dr Edwin N Broyles, 1100 N Charles St, Baltimore  
Place Drake Hotel, Chicago Time April 18-20, 1949

### AMERICAN LARYNGOLOGICAL ASSOCIATION

President Dr Frederick T Hill, 177 Main St, Waterville, Maine  
Secretary Dr Louis H Clerf, 1530 Locust St, Philadelphia 2  
Place Biltmore Hotel, New York Time May 16-17, 1949

### AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOTOLOGICAL SOCIETY, INC

President Dr John J Shea, 1018 Madison Ave, Memphis, Tenn  
Secretary Dr C Stewart Nash, 708 Medical Arts Bldg, Rochester 7, N Y  
Place Drake Hotel, Chicago Time April 18-20, 1949

## SECTIONS

Eastern—Chairman Dr Harold G Tobey, 403 Commonwealth Ave, Boston  
Southern—Chairman Dr Watt W Eagle, Duke University, Durham, N C  
Middle—Chairman Dr Dean M Lierle, University Hospital, Iowa City  
Western—Chairman Dr Leland G Hunnicutt, 98 N Madison Ave, Pasadena,  
Calif

### AMERICAN OTOTOLOGICAL SOCIETY

President Dr Marvin F Jones, 121 E 60th St, New York  
Secretary Dr Gordon D Hoople, Medical Arts Bldg, Syracuse 3, N Y  
Place Biltmore Hotel, New York Time May 18-19, 1949

### AMERICAN OTORHINOLOGIC SOCIETY FOR THE ADVANCEMENT OF PLASTIC AND RECONSTRUCTIVE SURGERY, INC

President Dr Samuel F Kelley, 47 E 61st St, New York 21  
Secretary Dr Norman N Smith, 291 Whitney Ave, New Haven 11, Conn

### AMERICAN SOCIETY OF OPHTHALMOLOGIC AND OTOLARYNGOLOGIC ALLERGY

President Dr Rea E Ashley, 384 Post St, San Francisco  
Secretary-Treasurer Dr Joseph Hampsey, 806 May Bldg, Pittsburgh 22

\* Secretaries of societies are requested to furnish the information necessary to keep this list up to date

## ABSCESS OF THE FRONTAL LOBE SECONDARY TO ETHMOIDITIS

JOSEPH H. KLER, M.D.  
NEW BRUNSWICK, N. J.

**A**BSCESS of the brain is a rare complication of sinusitis in general and an extremely rare complication of ethmoiditis in particular. In a series of 14,534 autopsies at the London Hospital, Evans<sup>1</sup> found 194 cases of brain abscess, and in only 14 of these was the condition rhinogenic. Onodi<sup>2</sup> reported 4 cases of rhinogenic brain abscess in a series of 13,400 autopsies, while Courville and Rosenzold<sup>3</sup> reported 2 cases of brain abscess in their series of 15,000 autopsies. The vast majority of these abscesses were due to infection of the frontal sinus. In Eagleton's<sup>4</sup> series of 104 abscesses of the frontal lobe only 9 were due to infection limited to the ethmoid sinus. The author has found no record of brain abscess due to infection limited to the ethmoid sinus in the literature during the past seventeen years.

Sinusitis is a very common medical entity, and in my experience ethmoiditis is commoner than infection in the other paranasal sinuses. It seems rather strange that such a frequent infection in an area of the body that seems so vulnerable should be so relatively free of intracranial complications. All surveys of complications of ethmoidal infection corroborate Dreyfuss's<sup>5</sup> findings: (1) that fatal complications of ethmoiditis usually follow the acute form of the disease and that the ethmoid cells are seldom exclusively involved, (2) that infection usually travels by way of the lamina cribrosa to the intracranial space and (3) that therefore septic meningitis is the commonest complication. Cour-

From the Department of Ophthalmology and Otolaryngology, St. Peter's General Hospital.

1 Evans, W. Pathology and Aetiology of Brain Abscess, *Lancet* **1** 1231 (June 6) 1289 (June 13) 1931.

2 Onodi, A. The Oculo-Orbital Intra-Cranial and Cerebral Complications of Diseases of the Nasal Accessory Sinuses, *Laryngoscope* **19** 801 (Nov.) 1909.

3 Courville, C. B., and Rosenzold, L. K. Intracranial Complications of Infections of Nasal Cavities and Accessory Sinuses. Survey of Lesions Observed in Fifteen Thousand Autopsies, *Arch. Otolaryng.* **27** 692 (June) 1938.

4 Eagleton, W. P. Brain Abscess. Its Surgical Pathology and Operative Technique, New York, The Macmillan Company, 1922, pp. 23 and 249.

5 Dreyfuss, R. Zur pathologischen Anatomie der Brustdrüse. Die Krankheiten des Gehirns und seiner Adnexe in Gefolge von Nasenerkrankungen, *Jena, G. Fischer*, 1896, pp. 45 and 46.

ville and Rosenfold, in their exhaustive study, found thrombosis of the cavernous sinus the second most frequent complication. McKinney<sup>6</sup> reported a fatal case of brain abscess following osteomyelitis of the frontal bone due to an original infection limited to the ethmoid sinus. Rugg Gunn and Suggitt<sup>7</sup> reported many more intracranial complications of acute sinusitis than of chronic sinusitis. In Maxwell's<sup>8</sup> series of 1,268 cases of acute and chronic sinusitis there were 22 deaths due to complications of the sinusitis, and of these 3 were due to ethmoiditis.

There must be a logical explanation for this unusual circumstance. It must be agreed that the location of the ethmoid sinuses is an extremely vulnerable one—separated from the brain, orbit and other sinuses only by thin bony walls. The anatomic location of the ethmoid sinus, therefore, does not explain the infrequency of intracranial complications of ethmoidal infection. The explanation must be in the intrinsic structure of the ethmoid sinuses together with the nature of their blood supply.

Van Alyea's<sup>9</sup> classic description of the ethmoid labyrinth bears repeating (in part) because it throws much light on this subject. He found greater variability in the anatomic characteristics of the ethmoid sinus than in the other sinuses, and he also found more pathologic change in the mucosa of the unusually large and variable ethmoid cells. According to his description, the ethmoid labyrinth is divided by various bony lamellas, and the ground plate of the middle turbinate divides the labyrinth into the two major sections, the anterior and the posterior. He stated:

These two major groups of cells are further divided by the lamellas of the remaining turbinates and accessory turbinate. [The lamellas normally prevent communication between groups of cells.] Ethmoid cells commonly drain into grooves. These form fairly parallel lines along the face of the upper lateral nasal wall. They are the hiatus semilunaris and the bullar ostium in the middle meatus, the posterior groove in the superior meatus and the postreme groove in the supreme meatus. One groove may accommodate the ostiums of several cells or may be the wide drainage space of 1 cavity. Occasionally the ostiums of cells are located outside the normal drainage groove, and this tends to isolate these cells from the others of a group. Cells draining into a common area should be similarly involved in an infective process. It is for this reason that

6 McKinney, R. Osteomyelitis of the Frontal Bone, *Arch Otolaryng* 28:1 (July) 1938.

7 Rugg Gunn, M. A., and Suggitt, S. C. Brain Abscess, *J Laryng & Otol* 57:55 (Feb) 1942.

8 Maxwell, D. Analysis of the Statistical Tables for the Years 1907 to 1926 Inclusive, Covering a Period of Twenty Years, *J Laryng & Otol* 44:105 (Feb) 1929.

9 Van Alyea, O. E. Ethmoid Labyrinth. Anatomic Study with Consideration of the Clinical Significance of Its Structural Characteristics, *Arch Otolaryng* 29:881 (June) 1939.

the maxillary sinus, the infundibular cells and occasionally the frontal sinus are simultaneously infected. For the same reason bullar cells, which have a separate drainage ostium, often escape an infection involving all other anterior cavities.

Although the bony structure of the ethmoid labyrinth is thin, the bone is of a compact, dense lamellar type. The blood supply of the ethmoid bone is by way of the ethmoid branches of the ophthalmic artery, and there are rich anastomoses with surrounding arteries. The venous drainage is also complex, being principally into the ethmoidal veins, which empty into the ophthalmic veins. These veins communicate with those of the dura and the superior sagittal sinus. Schaeffer<sup>10</sup> also described an anterior ethmoidal vein which passes through the cribriform plate and connects with the venous plexus of the olfactory bulb and the frontal lobe of the brain. Kramer and Som<sup>11</sup> found that the venules of the mucoperiosteum communicate with the large cranial sinuses and with the veins of the dura. These perforating venules are surrounded by perivascular spaces, which are probably lymph channels communicating with the intracranial contents. The lymphatic drainage of the sinuses is principally into the retropharyngeal nodes. The subdural space communicates indirectly with the extracranial lymphatics and directly with the perineural spaces of the olfactory nerve filaments. Thus there is a complex structure completely encased by dense lamellar bone with few dehiscences, with an unusually rich blood supply and with a lymphatic drainage principally away from the intracranial contents.

This anatomic arrangement is exceptionally good for the prevention of spread of the usual low grade infections. The cells of the ethmoid labyrinth are arranged in groups, each having separate ostia for drainage. Even though the septal walls are thin, the bone resists infection, and the infective process in any group of cells is kept reasonably isolated to permit of its control by the natural defense mechanism of the body. In an acute and virulent infection this mechanism is not adequate. Kramer and Som were impressed with the formation of submucosal abscesses. At the site of the submucosal abscess there is then developed an osteitis with eventual necrosis of the bone. Since the interseptal walls are the thinnest, they will break down first, and there is developed an empyema of the sinus. The coalescence of cells can be followed by roentgenologic studies. The lamina papyracea is the next vulnerable wall, and when it is destroyed the ethmoidal infection produces a subperiosteal abscess of the orbit. If the acute infection is not

10 Schaeffer, J. P. *The Nose, Paranasal Sinuses, Nasolacrimal Passages, and Olfactory Organ in Man*, Philadelphia, P. Blakiston's Sons & Co., 1930.

11 Kramer, R., and Som, M. L. *Intracranial Pathways of Infection from Diseases of the Sphenoid and Ethmoid Sinuses*. *Arch. Otolaryng.* 32: 744 (Oct.) 1940.

controlled it develops into meningitis or thrombosis of the cavernous sinus. However, destruction of the roof of the ethmoid sinus can produce localized meningitis, followed by the development of a subcortical abscess. I report here a case illustrating this complication.

It is my belief that chronic infection in the ethmoid sinuses is the principal cause of brain abscess of ethmoid origin. The extension of the infection is by contiguity, either by osteitis, causing local necrosis with subsequent local meningitis, encephalitis and formation of subcortical abscess, or by thrombophlebitis of any of the veins communicating with the dura. There seems to be no uniformity in the type of infecting organism. The bacteria reach the subcortical tissues and set up the usual reaction to inflammation. Its extent depending on the virulence of the organism and the resistance of the body, an attempt is made by the brain tissue to wall off the infection. This walling off is the formation of a capsule. A capsule forms in about three to four weeks according to Alpers,<sup>12</sup> although Kaplan<sup>13</sup> reported a case in which a capsule formed only after six weeks. If the path of invasion remains it is the classic "stalk." There is much difference of opinion on the presence of a stalk in abscess of the frontal lobe in general. Eagleton did not find a stalk frequently, but Atkinson<sup>14</sup> stated that he found a point of entry on the dura in all cases of adjacent abscess of the brain.

The symptoms of brain abscess depend on the stage of development and the location of the infection. Craig and Adson<sup>15</sup> stated the belief that meningitis, encephalitis and abscess of the brain are merely stages of development of the process. Specifically, the clinical picture presented by patients with brain abscess depends on the following factors: (1) the presence of infection, (2) the presence of an intracranial mass giving rise to increased intracranial pressure and (3) localizing symptoms referable to the portion of the brain involved. Any or all of these manifestations may be present, either alone or in any combination. It is not the purpose of this paper to review all known symptoms but rather, to present the clinical picture of the 3 cases of abscess of the frontal lobe of ethmoid origin which I have encountered and to emphasize the lessons I have learned, in the hope that they will be of some value to others.

#### REPORT OF CASES

*Acute Abscess of the Frontal Lobe*—This type of abscess is the result of an acute and a virulent infection to which the patient has not

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12 Alpers, B. J. Abscess of the Brain. Relation of the Histologic to the Clinical Features, *Arch Otolaryng* **29** 199 (Feb) 1939.

13 Kaplan, A. Abscess of the Brain, *Arch Otolaryng* **29** 385 (April) 1935.

14 Atkinson, M. Otogenous Cerebellar Abscess, *Ann Otol, Rhin & Laryng* **47** 1020 (Dec) 1938.

15 Craig, W. M., and Adson, A. W. Abscess of the Brain, *S Clin North America* **17** 1077 (Aug) 1937.

been able to develop an adequate resistance. It is found as a complication of acute ethmoiditis as a rule. This condition is well illustrated by the following case which I observed.

CASE 1—A 5 year old child, critically ill, was first seen by me on the day of admission to the hospital. There were typical findings of acute ethmoiditis and periorbital abscess together with nuchal rigidity. The diagnosis of ethmoidal empyema and periorbital abscess was immediately made, and because of the seriousness of the child's condition it was decided to drain the orbital and the sinusal infection at once and then determine the exact nature of the intracranial complication. The orbital abscess was drained through an external incision, and the ethmoid sinus was drained intranasally. Both the orbital and the sinusal abscess were extremely large, and when the pus was cleaned away the roof of the ethmoid sinus was found to be necrotic. After careful removal of the necrotic bone, an extradural abscess was entered, and a fistulous tract to a subcortical abscess was found. The infections, although extensive, were well walled off. Drainage and chemotherapy resolved the condition successfully.

The diagnosis of brain abscess was presumptive, of course, but in general the determining factors were the history of an infection of the upper respiratory tract, followed by the obvious presence of a sinusal infection, a periorbital abscess and signs of meningeal irritation and increased intracranial pressure. As Grant<sup>16</sup> stated, such a chain of events makes the diagnosis virtually inescapable. The treatment of acute abscess of the brain is much more difficult than making the diagnosis. Present methods of treatment of sinusitis have reduced the incidence of acute abscess of the brain, as has been observed by Davidoff<sup>17</sup>. The sinusal infection, and the orbital infection, if present, must be treated first. Chemotherapy and appropriate drainage are necessary. In Grant's<sup>16</sup> opinion the primary focus of a suspected adjacent abscess should be eradicated before the abscess is drained—first, because the operation may show the area in which the infection has passed through the bone to the dura and thus help in suggesting the position of the abscess and, second, because, unless the primary focus has been eliminated, reinfection of the cavity of the abscess may occur and nullify an apparently successful drainage.

*Chronic Abscess of the Frontal Lobe*—This type of abscess is as a rule an insidious, asymptomatic condition that can easily progress to a critical stage before the patient seeks medical attention. The following 2 cases well illustrate the problem encountered.

CASE 2—A man had a history of a low grade chronic ethmoiditis for many years. During inclement weather he would complain of increased nasal and

<sup>16</sup> Grant, F. C. Brain Abscess. Collective Review, Internat. Abstr. Surg. 72: 118, 1941, in Surg., Gynec. & Obst., February 1941.

<sup>17</sup> Davidoff, L. M. Brain Abscess, Clinics 4: 343 (Aug.) 1945.



postnasal discharge and headaches but did not seek medical attention during the ten years prior to the development of intracranial symptoms. He worked up to the day before admission to the hospital. His only complaint was an unbearable headache of about three weeks' duration. On examination he did not appear critically ill. There was pus in his right nostril, and a roentgenogram of the sinuses revealed cloudy ethmoid cells on the right. There was papilledema of about 3 D in both eyes. These examinations were performed on the first day of admission. The following day the patient had an unexpected crisis. He became unconscious, both eyes deviated to the left, and there was nuchal rigidity and swelling of the right upper eyelid. It was then quite evident that he had a brain abscess which had ruptured into the lateral ventricle. Although the patient was moribund, it was decided to explore the swelling of the right upper eyelid through a supraorbital incision. The floor of the frontal sinus and the roof of the ethmoid sinus were necrotic, and both sinuses contained pus. The posterior



Fig 1—Roentgenogram of the sinuses

wall of the frontal sinus was also necrotic, and on its removal an extradural abscess was revealed. This abscess had a sinus that apparently led to a subcortical abscess. The patient died the following day.

There are several lessons in this case, and the first and foremost is for one not to permit either the physician or the patient to regard chronic ethmoiditis lightly. It is a potential danger that must be guarded against. The second lesson is that diagnosis of chronic encapsulated abscess of the brain in the presence of a low grade infection in the ethmoid sinuses is difficult.

CASE 3—The patient was an intelligent man, and one who would not ignore evidence of illness. One day he reported to the medical department of his employer complaining of periodic blurring of vision and slight weakness of his "knee." The nurse referred him to me for an examination of his eyes.

The examination revealed papilledema of 6 D in the right eye and of 5 D in the left eye. There was no peripheral field defect although he had a large central scotoma, as would be expected. There were no other ocular signs. The left nostril had a few crusts of mucus, and there was questionable anosmia in the nostril. A roentgenogram of the sinuses revealed only cloudiness in the ethmoid sinuses on the left side (fig 1) and a roentgenogram of the skull indicated erosion about the sella, but the picture did not permit a definite diagnosis.

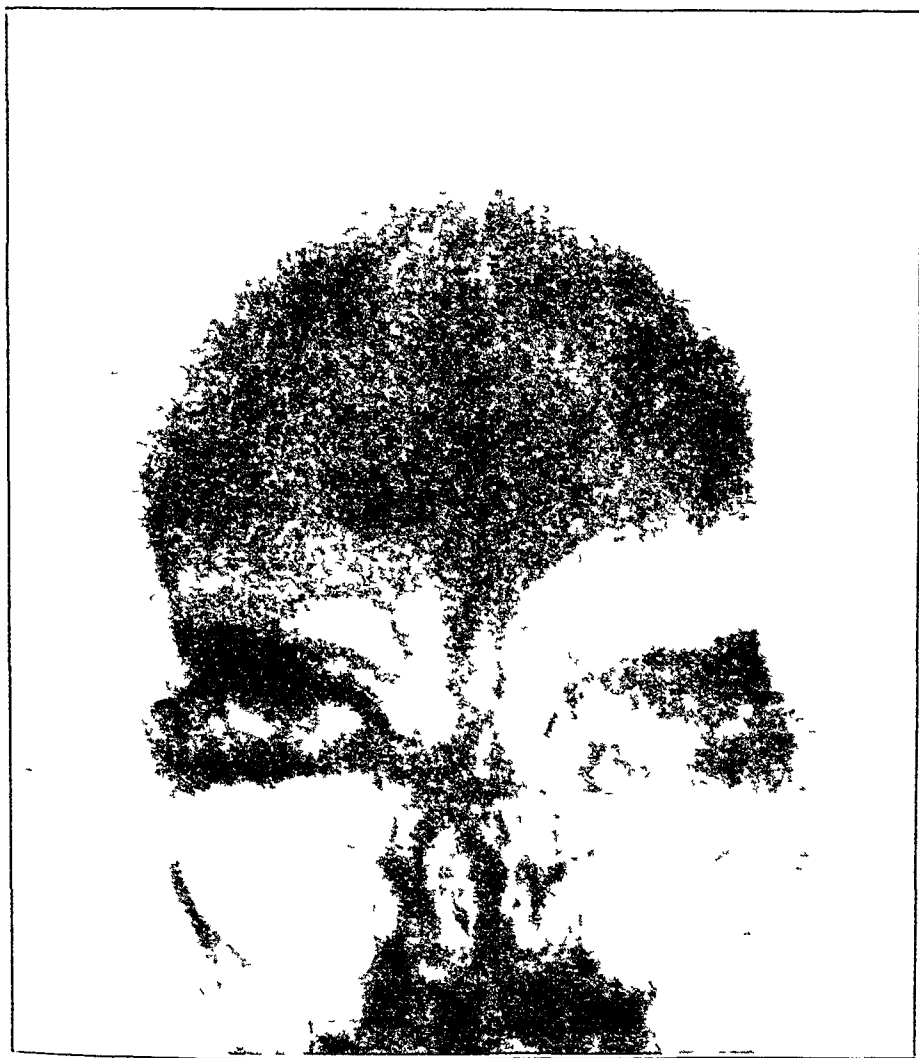


Fig 2—Roentgenogram of the skull and the sinuses

(fig 3) The patient also gave a history of having had sinus infection about five years previously, although he had not been conscious of any symptoms since that time. These findings did not warrant any diagnosis other than an intracranial mass. The patient was referred to Dr T S P Fitch for neurologic consultation. Dr Fitch found no focal signs on examination. However, the electroencephalogram indicated a brain abscess in the left frontal lobe (fig 4). At operation the diagnosis was confirmed. Dr Fitch found an abscess containing 200 cc of pus. The abscess had a fistulous tract leading to the left

ethmoid cells. The patient made a remarkable recovery, and a month later I performed an intranasal ethmoidectomy. He had an unusually large suprabullar cell which contained pus. I did not probe it to find whether there was a tract to the dura, but it was reasonable to suppose that this cell was the source of the infection because the other cells did not contain pus. At present this man is back at work and free from symptoms. His vision is 20/20, and there is no elevation of the disk margins. So far there has been no evidence of development of atrophy of the optic nerve. It seems inconceivable that a man could have a brain abscess containing 200 cc of pus and live, let alone be free from symptoms. If I had not had this patient under my care, I think that I should be skeptical of the possibility of such an occurrence.

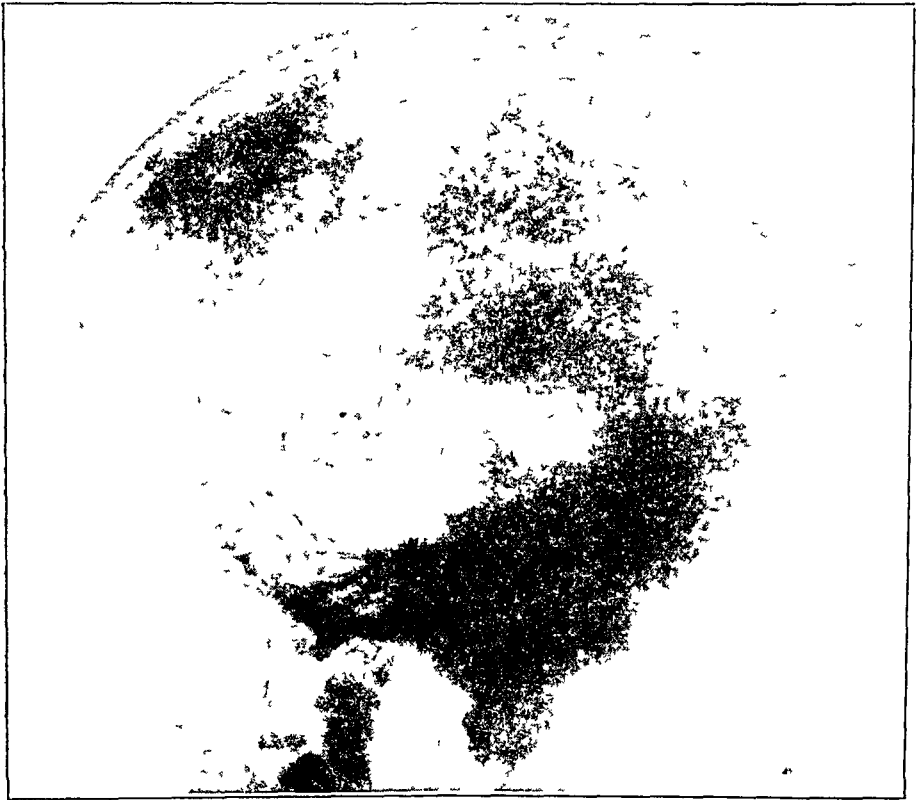


Fig 3—Roentgenogram of the skull

There are several lessons to be learned from this case also. An abscess of the brain may develop in ten days,<sup>18</sup> but it is my belief that in cases originating from ethmoiditis the abscess is of long standing. Cavenagh<sup>19</sup> reported a similar observation. It is my opinion that the patient develops a reasonable immunity to his sinus infection. However, acute coryza or other infections of the upper respiratory tract introduce

18 Kleinfeld, L. Abscess of Frontal Lobe Secondary to Frontal Sinusitis, *J Mt Sinai Hosp* 9 96 (July-Aug) 1942

19 Cavenagh, J. B. A Case of Left Frontal Lobe Abscess Complicating Chronic Sinus Infection, *J Laryng & Otol* 51 239 (April) 1936

new bacteria, and with each succeeding reinfection there is further destruction of the mucosa of the ethmoid cells. The observations of Kramer and Som<sup>11</sup> give a logical explanation of the formation of localized areas of osteitis and necrosis of the roof of the ethmoid sinus. Because the infection is not a very virulent one and because the area of perforation is small, the localized meningitis may be entirely asymptomatic as far as the patient is concerned. Because the submucosal abscess is encapsulated it will feed infection through the break in its capsule at the point of the osteitis to the meninges, with resulting encephalitis and subsequent formation of a subcortical abscess. The low virulence of the bacteria favors the formation of a capsule about the brain abscess. When this is accomplished there is a low grade infection

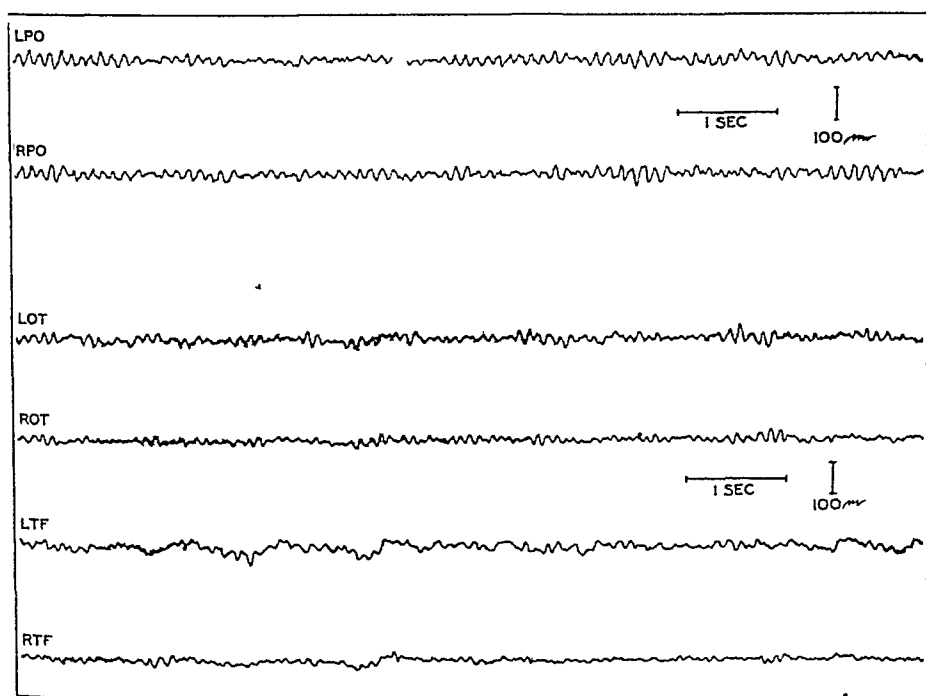


Fig 4—Electroencephalographic tracings. LPO indicates left parieto-occipital, RPO, right parieto-occipital, LOT, left occipitotemporal, ROT, right occipitotemporal, LTF, left temporofrontal, and RTF, right temporofrontal. The upper two tracings are from a normal subject and the others from the patient in case 3.

in the ethmoid sinus to which the patient has a reasonable tolerance and a walled-off infection within the brain substance which will give no septic symptoms or localizing symptoms in the early stages. Bertolet<sup>20</sup> reported a massive abscess of the frontal lobe that had many of the characteristics cited. Even though this condition is rare, I should like to emphasize the lessons these 2 cases have taught me. The diagnosis

<sup>20</sup> Bertolet, J. A. Atypical Massive Abscess of Frontal Lobe, Arch Otolaryng 28 621 (Oct) 1938.

is not easy Smith<sup>21</sup> emphasized the value of the sedimentation test, but in the presence of a sinus infection this test is not significant King<sup>22</sup> stressed the diagnostic importance of unilateral anosmia, but its presence is also difficult to interpret because many patients with chronic sinus infections have a reduced sense of smell Kaplan<sup>23</sup> reported that encapsulated and uncomplicated abscesses of the brain frequently produce no signs of fever, leukocytosis or toxemia Giant<sup>16</sup> emphasized the presence of papilledema in all cases of chronic encapsulated abscess This has been the only constant finding in my cases Headache is stressed by all authorities It is my belief that in the type of abscess here described headache is a late symptom, and one that should be regarded as a danger signal The electroencephalogram is an invaluable diagnostic aid The cooperation of the neurosurgeon is essential I fully realize that the treatment of abscess of the brain was pioneered by rhinologists, and I have the greatest respect for the late Dr Eagleton and the many prominent rhinologists who followed him in the development of this field However, I feel that the average rhinologist will do well to ask the aid of the neurosurgeon in both the diagnosis and the treatment of this baffling and obscure condition This series of cases is too small for me to be dogmatic about conclusions, but the similarity of the cases is striking

#### SUMMARY AND CONCLUSIONS

Brain abscess as a complication of acute and of chronic ethmoiditis is discussed

An explanation of this condition on an anatomic and physiologic basis is made

Complications of acute ethmoiditis are more frequent and more easily diagnosed than those of the chronic infection

Chronic abscess of the brain as a complication of chronic ethmoiditis is an encapsulated abscess that gives few general or localizing signs

Chronic abscesses of ethmoidal origin produce few symptoms and signs, papilledema was the most constant finding

Electroencephalography is an invaluable aid in the diagnosis of this type of intracranial complication

The assistance of the neurosurgeon in the management of these cases is essential

151 Livingston Avenue

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21 Smith, G W Clinical Observations on Twenty Proven Cases of Brain Abscess, U S Nav M Bull **38** 358 (July) 1940

22 King, J E J Symposium on Brain Abscess Laryngoscope **50** 1146 (Dec) 1940

23 Kaplan, A Symposium on Brain Abscess Laryngoscope **50** 1159 (Dec) 1940

## SURGERY OF THE CHRONICALLY DISCHARGING EAR

HOWARD P. HOUSE, M.D.  
LOS ANGELES

THE PURPOSE of this presentation is to stress certain important anatomic landmarks and surgical maneuvers which have proved extremely valuable to me in developing a technic of endaural temporal bone surgery.

The endaural incision is slightly changed from the original Lempert<sup>1</sup> technic in that the no. 1 incision (A) is placed more external in the skin of the ear canal. The no. 2 incision (B) is completed in the usual way, and the no. 3 incision (C) follows the edge of the conchal cartilage.

The incision is first outlined in gentian violet before local infiltration of the area with procaine hydrochloride obscures the usual landmarks. A Bard-Parke<sup>1</sup> knife with a no. 15 blade is used to make the incision. A small tiagus retractor replaces the Lempert ear speculum for this procedure. The triangular piece of skin removed is very small, and the entire incision is extracartilaginous. This incision allows greater preservation of tissue for later use as a skin flap in lining the mastoid cavity. This same endaural incision is used in all surgical procedures on the temporal bone.

After the self-retaining retractor is placed in position, a small elevator is used to elevate the periosteum over the zygomatic area. The triangular piece of fascia extending from the posterior membranous ear canal wall to the temporal muscle is then excised, care being taken to avoid the temporal muscle above and the superior membranous ear canal wall below. This procedure provides a more adequate exposure anteriorly toward the zygoma and eliminates the necessity of spreading the no. 2 endaural incision postoperatively in order to avoid atresia of the ear canal.

The horizontal canal has long been recognized as the most important landmark in temporal bone surgery. It is interesting to note that an

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Read in part and illustrated by a motion picture before the Section on Laryngology, Otology and Rhinology at the Ninety-Seventh Annual Session of the American Medical Association, Chicago, June 27, 1948.

<sup>1</sup> Lempert, J. Endaural Antauricular Surgical Approach to the Temporal Bone. Principles Involved in This New Approach, Summary Report of 1,780 Cases, Arch Otolaryng 27 555-587 (May) 1938.

imaginary line drawn directly posterior from the superior margin of the external bony ear canal will invariably bisect the horizontal canal deeper in the temporal bone. This is a great aid in visualizing the location of the antrum and aditus before any bone work is carried out. This valuable guide should be stressed in the teaching of surgical technic of the temporal bone.

The mastoid cortex and underlying cells are removed by the burr method. I have found it expedient to autoclave the entire dental arm together with the belt and the engine pulley. The sterilized engine pulley is replaced on the engine shaft by means of a sterile screw driver. More recently I have been wrapping the engine pulley in alcohol-soaked gauze, leaving it attached to the engine shaft. Repeated cultures have proved this technic to be sterile. This procedure eliminates the dental arm sleeve, which so frequently becomes entangled in the belt and pulley.

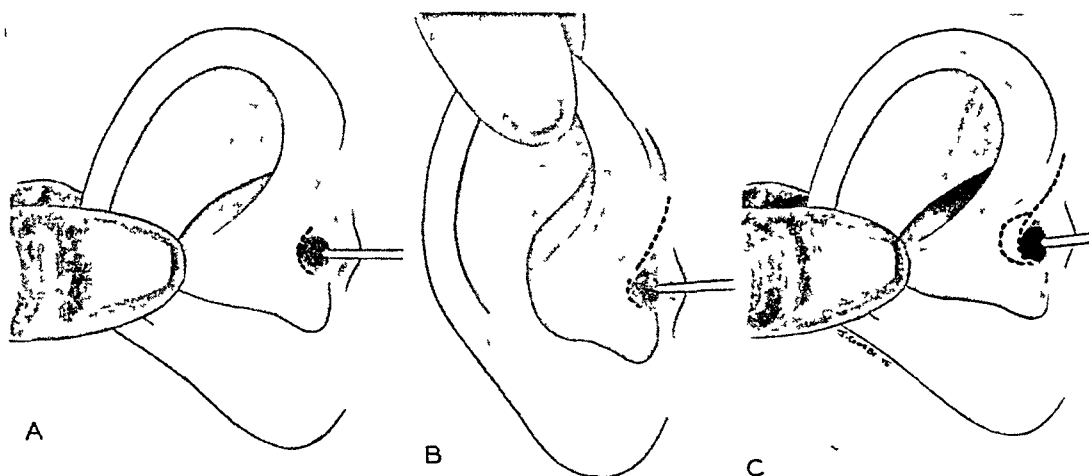


Fig 1—Endaural incision

wheels. This method can be used only if the S S White Dental Arm is attached to the engine. This arm fits either the S S White or the Emesco Portable Dental Engine.

I use the perforating burr to enter the antrum. If the perforating burr is used properly, it will invariably enter the antrum without undue complications. The point of entrance of the perforating burr is such that an imaginary line drawn directly posterior from the superior margin of the external bony ear canal wall will cross the upper margin of the completed perforating burr hole. A line drawn directly superior from the posterior margin of the external bony ear canal wall will cross the anterior margin of the completed perforating burr hole.

The perforating burr must enter the bone at right angles to the patient's skull and must never penetrate the mastoid bone to a greater depth than that of the cutting portion of the burr. If these directions are invariably followed, one will not injure the dura superiorly, regardless of the amount of overhang, nor will one enter the lateral sinus regardless of its far anterior position.

The mastoid cells are exenterated by means of cutting burrs of various size. For reasons of safety, the nearer one is to the lateral sinus or dural plate the larger should be the burr. As these structures are approached there is a change in the sound of the burr, and slight bleeding may occur. A large burr is used to thin the posterior bony ear canal wall to a width of 1 or 2 mm. If the posterior bony ear canal

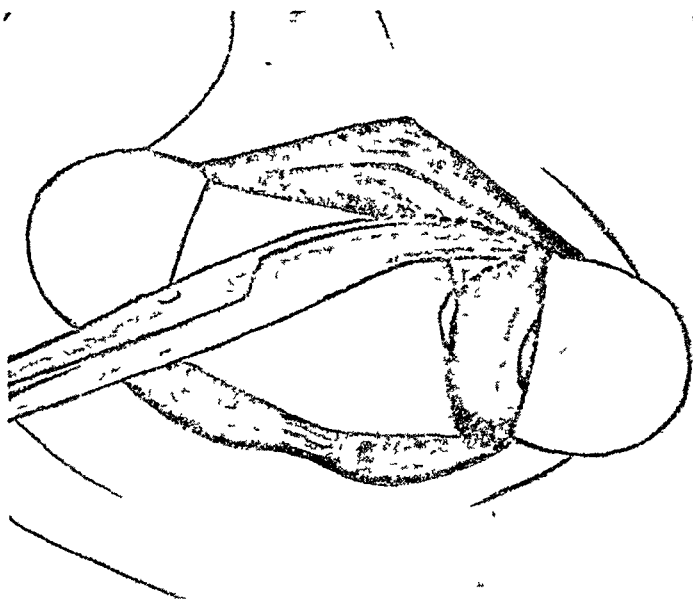


Fig 2—Triangular fascia grasped with hemostat and severed

wall is adequately thinned and the dural plate is exposed directly superiorly, the posterior portion of the horizontal canal will be immediately visible and will invariably be bisected by the imaginary line drawn directly posterior from the superior margin of the external bony ear canal wall.

After the posterior bony ear canal wall has been adequately thinned, the dural plate exposed and the horizontal canal identified, a small burr is used to remove the zygomatic cells. These cells are removed from an external to internal approach and in a posterior to anterior direction between the dural plate superiorly and the superior margin of the external bony ear canal inferiorly. By this approach a definite shelf of thin, firm cortical bone will be exposed, which forms the external wall of the epitympanum. This landmark is constant in both wide and narrow



angle cases, and its importance has not been adequately stressed in the literature. The opening of the aditus is a triangle bounded by the dural plate superiorly, the bony shelf externally and the horizontal canal internally. If this shelf technic is followed, probing of the aditus, which may result in dislocation of the incus, is totally unnecessary. Exposure of the bony shelf completes the simple mastoidectomy, if one chooses to perform this procedure endaurally.



Fig. 3—Note that a line drawn posteriorly from the superior margin of the bony canal bisects the horizontal canal deeper in the temporal bone.

#### MODIFIED RADICAL MASTOIDECTOMY

This operation is a continuation of the simple mastoid procedure just described. The thin bony shelf overlying the epitympanum is carefully removed with the use of a small curet. The removal is begun superiorly near the dural plate. In this way the short crus of the incus which lies just under the inferior margin of the bony shelf is not disturbed. Complete exposure of the entire short crus of the incus and malleus head and neck denotes an adequately thinned posterior-superior bony ear canal wall and bridge. These structures, therefore, should

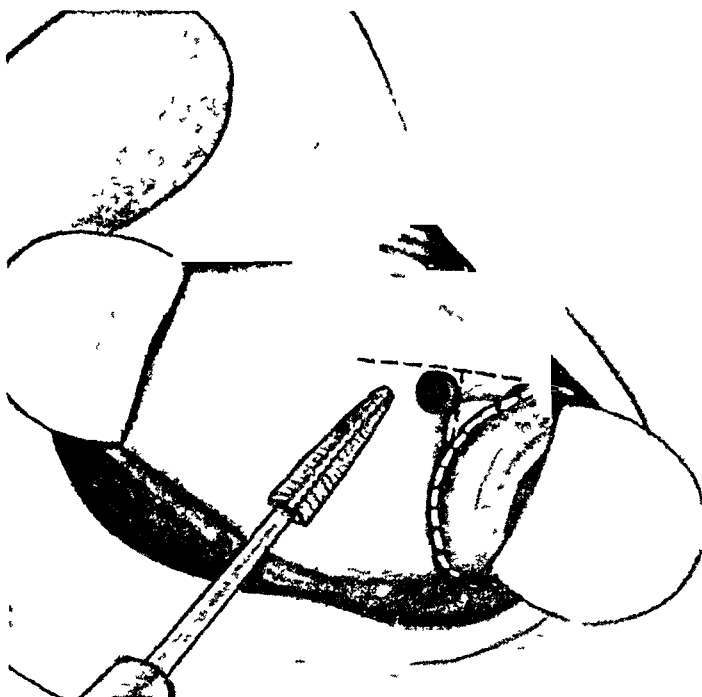


Fig 4—Note the exact position of the perforating burr hole in relation to the external bony ear canal wall

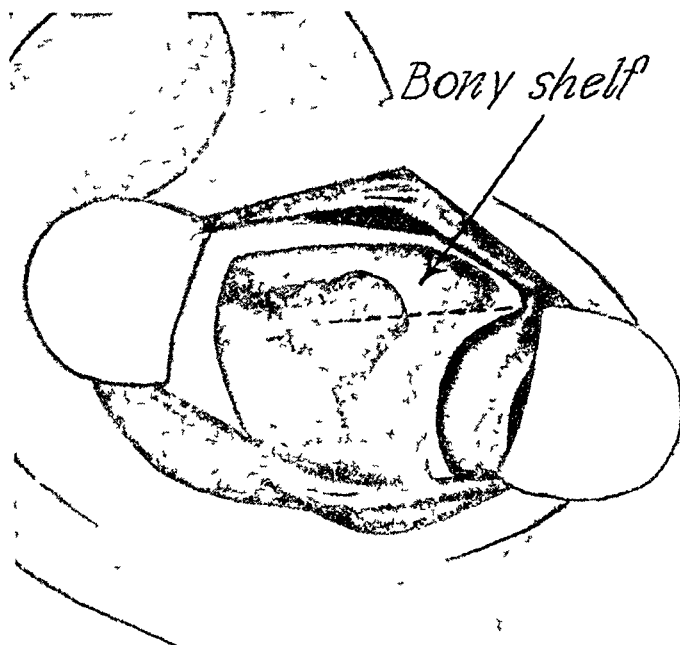


Fig 5—Note the bony shelf overlying the epitympanum (imaginary line bisects horizontal canal)

be visualized before the posterior-superior bony ear canal wall is taken down. In cases in which there is an extremely narrow angle it may be necessary to remove the posterior-superior bony ear canal wall before complete exposure of the incompleolai joint can be accomplished.

The membranous ear canal is separated from the posterior-superior bony canal wall in its line of cleavage and the bony wall removed with a narrow rongeur. A narrow Lempert elevator is then inserted between the membranous canal wall and the remaining bony bridge. This elevator must pass into the middle ear parallel to the short crus of the

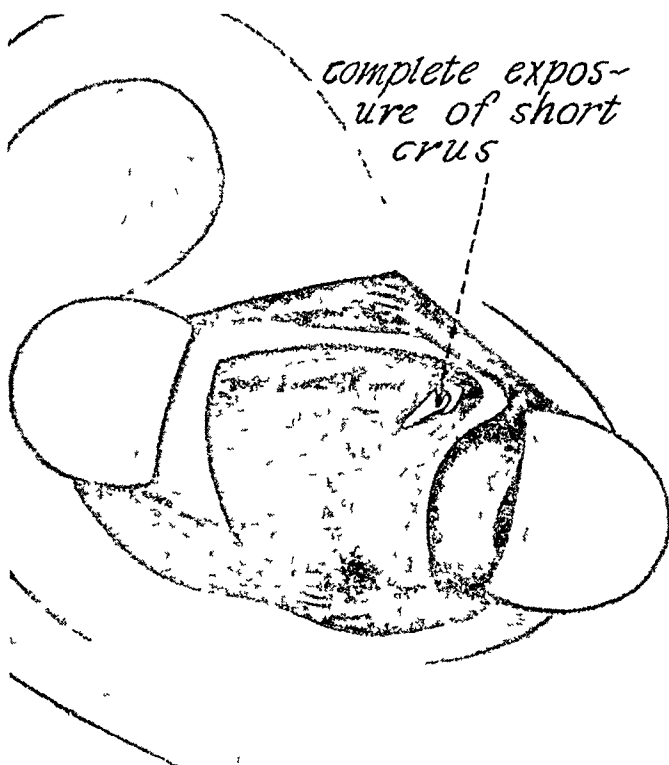


Fig 6—Both sides of short crus should be noted before the posterior bony canal wall is removed. (In cases in which there is a narrow angle this cannot always be accomplished.)

incus and must hug the bone in order to avoid tearing the thin membranous ear canal wall. A Lempert rongeur is then inserted over the thinned bony bridge, the superior blade being allowed to rest gently on the short crus of the incus. This maneuver assures the proper depth of the blades before the bony bridge is bitten through. After removal of the bony bridge and the protruding annular ring margins, the epitympanum and its contents are fully exposed to direct view.

A bloodless field is created by repeated use of epinephrine packs of 1 to 1,000 dilution. With magnification, all pathologic tissue, whether

granulation or cholesteatoma, is carefully removed from about the incudomalleal joint area, a small eye spud coupled with gentle suction being used. Some pathologic tissue can also be removed from the upper portion of the middle ear, including the stapes and the stapedius tendon area, without interrupting the continuity of the ossicular chain and its supporting ligaments. If necrosis is found in the ossicular chain so that its continuity has been disturbed, then the incus and the head and neck of the malleus are removed.

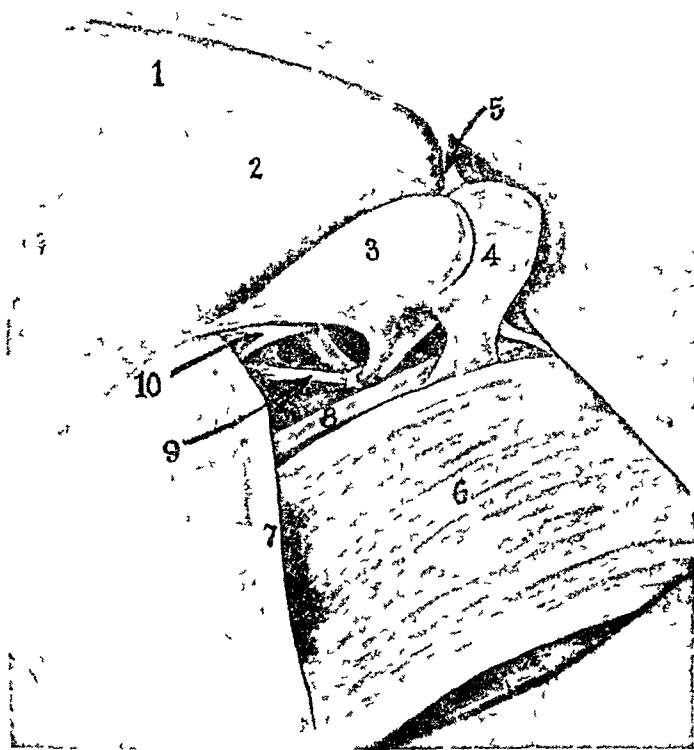


Fig 7—This exposure completes the modified radical mastoidectomy when the membranous ear canal is left intact. (1) superior canal, (2) horizontal canal, (3) incus, (4) malleus, (5) suspensory ligament, (6) membranous ear canal wall, (7) facial ridge, (8) chorda tympany nerve, (9) stapedius tendon, (10) fallopian canal.

In the customary modified radical operation a flap is created from the posterior-superior membranous canal wall and placed over the epitympanum much the same as in the fenestration operation. If the epitympanic pathologic tissue has been satisfactorily removed, I do not create a skin flap but prefer to allow the cavity to heal as in a simple mastoidectomy. In this case the wound is closed by suturing the skin edges of the no. 2 and the edges of the no. 1 and no. 3 incisions together.

and placing a small rubber drain in the cavity. By this method, creation of a mastoid bowl or cavity, with its associated healing requirements, is eliminated. In my experience the attic perforation present usually closes spontaneously.

#### RADICAL MASTOIDECTOMY

If the membranous ear canal wall has been left intact, the radical mastoidectomy is simply a continuation of the completed modified radical operation. Any remnants of incus or malleus, as visualized in the epitympanum, are grasped and removed. The skin flap is prepared by separating the skin of the ear canal from the anterior-superior bony canal

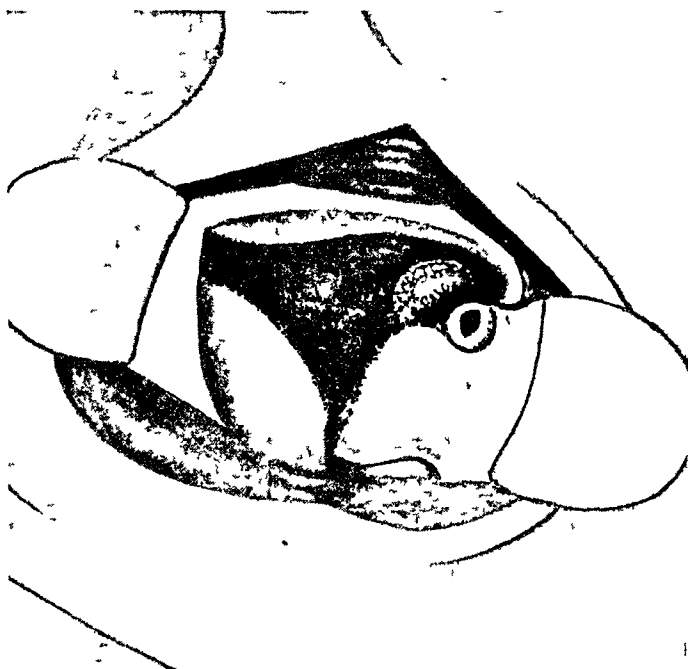


Fig 8—Note the skin flap extending posteriorly over the facial ridge

wall, allowing it to extend posteriorly over the facial ridge to epithelize the mastoid cavity. If one prefers, the entire skin of the ear canal can be excised completely over the facial ridge and discarded or preserved for later use as a free graft. In the event the skin flap is completely discarded, the mastoid cavity heals by fibrosis and the end result is an obliteration of the mastoid cavity and of most of the external ear canal. This procedure eliminates the mastoid bowl, with its problem of epithelization, but should not be used unless all pathologic tissue has been removed from the middle ear area. A skin flap should always be prepared, if one has reason to believe that all pathologic tissue within the middle ear cannot be removed or if the hearing in the opposite

ear is impaired. In the latter instance, a Pohlman<sup>2</sup> artificial ear may be used in an attempt to restore serviceable hearing in the ear operated on.

When the skin flap is preserved, an extremely thin, full thickness elliptical skin graft measuring 1.5 by 3 cm., taken from the postauricular area, has proved of value in decreasing postoperative drainage from the ear. Multiple punctures are made through the graft for drainage of blood serum, and the graft is divided into three portions. On completion of the surgical procedure, one piece is placed over the promontory and eustachian orifice and another over the epitympanum and dorsal plate

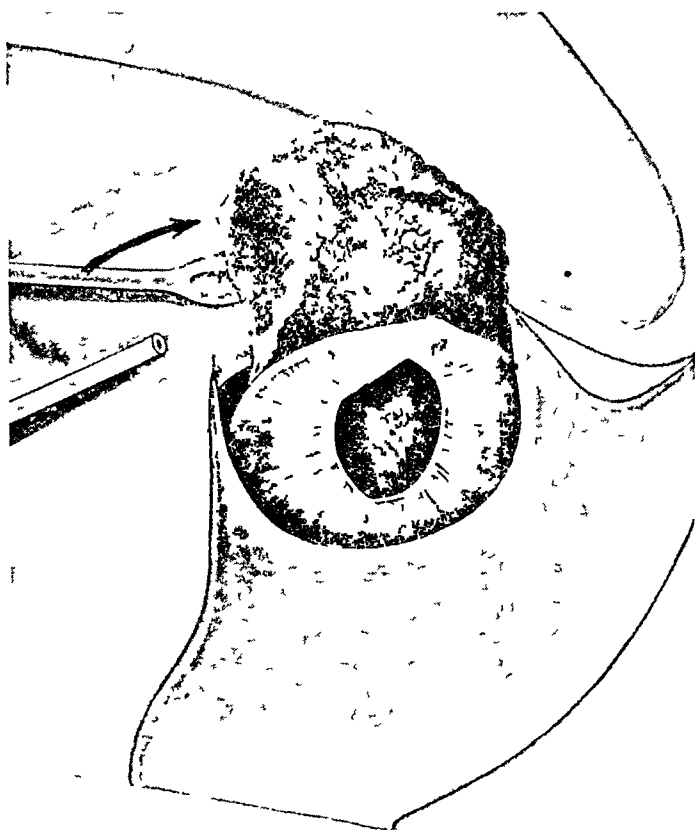


Fig. 9—The thickened periosteum with the overlying contents of the epitympanum is elevated.

region, and the third covers the sinodural angle. These pieces of skin are held in position by small balls of parresined<sup>®</sup> gauze, which are allowed to remain in place for five days.

*Identification of the Fallopian Canal*—Before entering the middle ear area it is imperative to visualize the fallopian canal. Most injuries to the facial nerve occur in the fallopian canal area and usually are the result of inadequate visualization of this canal. In the teaching of radical

<sup>2</sup> Pohlman, M. E. Artificial Middle Ear, *Ann. Otol., Rhin. & Laryng.* 56: 647-657 (Sept.) 1947.

mastoid surgery emphasis has too often been placed on avoiding the area of the fallopian canal in an attempt to prevent injury to the facial nerve. I feel that this teaching is wrong because it not only leads to more injuries to this nerve, due to lack of visualization, but also encourages the operator to leave considerable pathologic tissue about this area, which may result in continued damage after surgical intervention. Therefore, a technic has been developed to allow early visualization of this canal before any pathologic tissue is removed from the middle ear area.

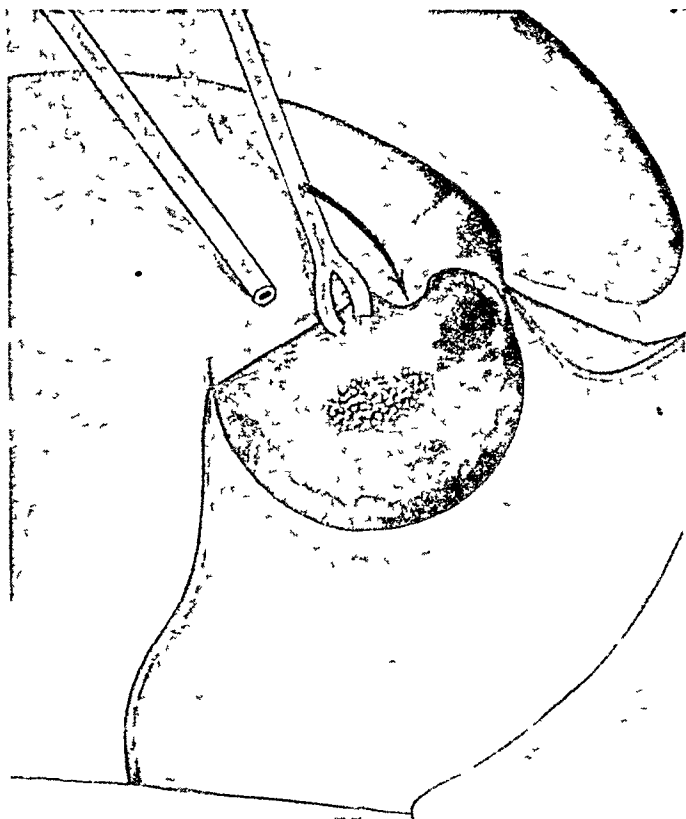


Fig. 10—The periosteum is elevated over the cochleariform process, exposing the fallopian canal to direct view.

After removal of the ossicular remnants and preparation of the skin flap, the posterior portion of the horizontal canal is visualized by again making use of the imaginary line drawn posteriorly from the superior margin of the external bony ear canal. If the ear has been operated on before, the facial ridge, consisting of the remaining part of the posterior bony ear canal wall, is identified and followed to its termination at the drum margin. The horizontal canal will be visualized just posterior to this area.

The thickened periosteum with all the overlying pathologic tissue is elevated in a posterior to anterior direction following the contour of the bony horizontal canal. This maneuver is best accomplished by the use of a small dull ring curet coupled with gentle suction.

This elevation is carried to the far anterior extremity of the horizontal canal, and then the ring curet is directed inferiorly over the cochleariform process into the middle ear. If one enters the middle ear before reaching the far anterior extremity of the horizontal canal and the cochleariform process, dislocation of the stapes may occur. As soon as the cochleariform process is exposed to view, the entire fallopian canal is clearly visualized, even before any surgical procedure is carried out within the middle ear. If this technic is routinely followed, I am confident that



Fig 11—Removal of the tensor tympani is routinely performed in radical mastoidectomy

fewer injuries to the fallopian canal will occur in radical mastoid surgery. "What one sees he will not injure." At this point I must again emphasize the importance of a dry surgical field, adequate illumination and proper magnification.

All pathologic tissue may now be removed from the middle ear area with little fear of injury to the facial nerve. The cochleariform process is fractured by elevating it in an external inferior direction away from the fallopian canal. The tensor tympani is raised from its bony groove by means of a small curet and removed intact.

The inferior margin of the annular ring is removed in order to expose adequately and allow thorough curettement of the hypotympanic area. The eustachian tube orifice is curetted with a no. 0000 Lempert curet and cotton oxygel is placed in the tubal orifice to add support.



to the skin graft. The patient is urgently requested not to blow his nose for a period of two months after surgical intervention, in an attempt to allow complete epithelization to occur over the orifice of the tube.

*Removal of Granulations from the Stapes Area*—An ear may continue to drain after a radical mastoid surgical procedure because of infected granulation tissue remaining in the area of the stapes. I have found that these granulations can be removed with little risk of stapes dislocation if one uses a small eye spud and gently sweeps in a posterior



Fig. 12—Note direction of movement carried out to remove granulations from the stapes area.

to anterior direction above and below the stapedius tendon and stapes. In this way the counterpull of the stapedius tendon acts to prevent tilting of the stapes, whereas an anterior to posterior movement would immediately tilt the stapes from the oval window.

When continuity of the ossicular chain is interrupted, the stapedius tendon may, because of its counterpull, tend to tilt the stapes slightly in the oval window. It has recently been pointed out that this may

interfere with the phase differential between the oval and round windows and thereby interfere with hearing<sup>4</sup> It may be that hearing can be improved after radical mastoidectomy by routinely severing the stapedius tendon

#### SUMMARY

A few points in the technic of endaural bone surgery which have proved beneficial in operating for the chronically discharging ear are described .

1 A slight modification of the Lempert incision provides additional skin for later use in lining the mastoid cavity This same incision is used in all procedures on the temporal bone

2 Excision of a triangular piece of fascia extending from the posterior membranous ear canal wall to the temporal muscle provides additional exposure and eliminates the necessity of spreading the incision postoperatively in order to prevent atresia of the ear canal

3 An imaginary line drawn directly posterior from the superior margin of the external bony ear canal will bisect the horizontal canal deeper in the temporal bone

4 Elimination of the cloth sleeve over the dental arm by sterilization of the arm, belt and engine pulley has proved expedient

5 Identification of the constant firm bony shelf forming the external wall of the epitympanum has definite value

6 Except in occasional narrow angle cases, the entire malleus head and neck, together with the short crus of the incus, should be completely visualized before an attempt is made to remove the posterior-superior bony canal wall This exposure indicates that the bony ear canal wall has been adequately thinned

7 The narrow Lempert elevator must be parallel to the short crus of the incus as it enters the middle ear if the membranous ear canal tissue is to be separated from the bony bridge without injury

8 It is not necessary to create a skin flap in the modified radical operation if the pathologic tissue has been satisfactorily removed from the epitympanum

9 A skin flap may be created or completely removed in the performance of radical mastoidectomy A thinned, full thickness skin graft may be readily obtained from the postauricular area and, when used, seems to expedite healing of the cavity

10 Complete visualization of the fallopian canal early in the operation is a must if injury to the facial nerves is to be avoided

11 Granulations over the stapes area can be more safely removed if one uses a described posterior to anterior maneuver, which takes advantage of the counterpull of the stapedius tendon

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4 Bateman, G H    Personal communication to the author

12 Severance of the stapedius tendon routinely in radical mastoidectomy may result in improved hearing

#### CONCLUSION

An intimate knowledge of the surgical anatomy of the temporal bone is an absolute prerequisite in the performance of this operation of chronic otitis. Adequate illumination, proper magnification and the maintenance of a dry surgical field are of paramount importance if the desired results are to be obtained.

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#### ABSTRACT OF DISCUSSION

DR JOHN F. TOLAN, Seattle, Washington. Dr. House is to be commended on this outstanding presentation in which the technical difficulties encountered are indeed great. Because of widespread interest concerning surgery for the otosclerotic patient, endaural surgery was successfully launched about ten years ago. Lempert did much of the original work in this particular field, followed by Shambaugh, Meltzer, House, Walsh, Maxwell and many others. It has stimulated the otologist to endless research pertaining to the inner ear. Too little investigation regarding the cochlea was done previous to the fenestration operation. We have still not reached the final answer to this problem, but we are progressing along proper lines.

I have a few slides to reemphasize points already brought out by Dr. House in the advantages of the endaural approach. I should like to show the type of skin flap that I am using not only in endaural surgery for fenestrations but also for radical mastoidectomies. In some of my fenestrations and radical mastoidectomies I have encountered persistent postoperative discharge, and I believe this procedure has gone a long way in overcoming this difficulty. The first incision is begun in the membranous lining of the superior-posterior wall of the external auditory canal and the junction of its osseous membranous portions. It is carried straight downward parallel to the osseous membranous junction including one half of the circumference of the canal. The second incision is the same as Lempert's incision. It starts at the point of the first incision in the superior-posterior wall of the canal and is carried outward through the skin of the outer one half of the superior-posterior wall and is continued upward adjacent to the tragus into and along the anterior wall of the suprameatal triangle. The third incision starts at the lower edge of the first incision and runs externally along the floor of the canal through the lower end of the anterior border of the concha. This skin flap is then carefully separated from the under subcutaneous tissue and reflected posteriorly to and exposing the edge of the conchal cartilage. The subcutaneous tissue and the periosteum are then removed, exposing the mastoid cortex. An elliptic piece of the superior edge of the conchal cartilage is removed to create a larger endaural orifice. This skin flap later is folded over the edge of the exposed conchal cartilage. This procedure, I believe, reduces the instances of chondritis and shortens the postoperative care.

We are all familiar with the fact that the endaural approach is the most direct route to the mastoid antrum and middle ear structures, particularly the eustachian orifice. Bleeding is not a troublesome feature with this approach as it is with the postauricular procedure. The type of anesthesia depends on the patient,

varying from local anesthesia with nitrous oxide for some to oxygen and pentothal sodium® given intratracheally

Dr House has emphasized that this approach affords a better opportunity of cleaning out all diseased tissues in the mastoid antrum, epitympanum and perieustachian region. It is important that all vestiges of cholesteatomas and granulation tissue be removed. With the aid of the loop or Dr Shambaugh's microscope, this can carefully be carried out. Trauma to the soft tissues with this approach is at a minimum. Postoperative dressings are not painful. We do not have the ugly postauricular scarring defects and fistulas. The patient is out of bed on the second day and usually is out of the hospital between the third and fifth days. Economically, this is important to the patient, and the postoperative complications are greatly reduced.

DR JAMES E CROUSHORE, Detroit. The development of endaural surgery not only has been necessary for a practical technic in the fenestration operation but also has brought forth a refinement in temporal bone surgery for handling infection. I know several men who took a course in fenestration surgery and then went back to their practice but never performed a fenestration operation. Yet they consider the training most valuable because they learned the surgical anatomy of the temporal bone far better than they thought possible. They became adept at handling an electrically driven burr, they saw the importance of proper illumination and, above all, they discovered that by using magnification a new world in the temporal bone opened to them. Dr House's presentation has stressed these statements.

The use of the single incision preserves skin and gives a longer flap. If desired, the end of the flap may be amputated, and this piece of skin can be placed in the mastoid cavity as a graft. Excising fascia at the superoanterior aspect of the incision for better exposure and prevention of future atresia of the canal seems like a good procedure, which I will try in the future. Utilization of an imaginary line drawn directly posterior from the superior margin of the external bony ear canal to localize the horizontal semicircular canal deeper in the mastoid and thus aid in early finding of the antrum and aditus is a good idea in helping to keep oriented. The dental arm sleeve is always a nuisance and is a time killer because it gets caught between the pulleys and belt and it is difficult to manipulate the screw at the end of the handpiece through it. Elimination of the sleeve by autoclaving the dental arm together with the belt and engine pulley certainly would be a mechanical improvement.

Dr House made a good point when he stressed the outlining of the bony shelf which forms the external wall of the epitympanum. This bony landmark represents a definite "stop sign" in the complete or cortical mastoidectomy and a "go sign" in a more radical mastoidectomy.

If complete visualization of the fallopian canal is attained in every radical mastoidectomy, as Dr House suggested, there certainly would be fewer facial nerves injured. The destructive processes and the great amount of disease present in some ears may not permit such an orderly procedure as one would like. Considerable debris may have to be removed before any semblance of a middle ear is apparent. In these instances extreme caution is required so as not to injure the nerve, stapes or even the round window.

Dr House does not turn a skin flap in some modified radical mastoidectomies. I have not employed this procedure, but I believe it merits trial in carefully chosen cases. The decision can be made only during the operation.

In the modified radical mastoidectomy extreme care must be taken to avoid dislocating the incus. If good hearing is present—and this is one of the indications

for the modified procedure—the incus must maintain its normal position. Rarely will the hearing maintain the preoperative level once the incus is dislocated.

There are several ways of handling the skin flap in the radical operation. I have always utilized it in some manner and never discarded it. On several occasions I have cut the flap in its center in its long axis and turned the one half upward and the other down over the facial ridge.

I have had no experience with the Pohlman artificial ear. Properly employed, it should be effective in improving the hearing in ideal cases.

DR O POPPER, Johannesburg, South Africa. I should like to add my sincere admiration for the presentation of this paper. There is not the slightest doubt in my mind that the only reasonable operation to be done on a chronically infected mastoid is by the endaural route. But there is another group of cases in which the mastoid is sclerotic and in which you might think it is advisable not to disturb what, after all, is nature's method to seal off the infection.

I had the opportunity this morning of demonstrating a direct approach to the attic and antrum by the transtympanic route. When the mastoid shows signs of infection roentgenologically, obviously you must clear it out by the endaural route. But when you are reasonably sure that the mastoid is sclerotic and, as I say, healed, I should like to urge you to try the procedure of clearing only the atticoantral region by the transtympanic route. I hope that some who watched me doing it this morning were convinced. I have used this method in 27 cases, in each of which I have made sure that the mastoid is sclerotic; the results in this small series have been encouraging—rapid epithelization, shortened postoperative period of otorrhea and preservation of hearing. We have come to expect destruction of hearing in the radical operation!

The transtympanic approach is not a difficult operation and certainly less traumatic, but the main point about it is that if the hypotympanum is cleared at the same time and if the hypotympanum (that is, the region in the vicinity of the round window) can be kept clear, one will restore hearing as well as control discharge.

The point which I am trying to make is whether we could not shift the center of gravity in our operative outlook and decide that the first consideration in operating on any chronically diseased ear shall be that we shall restore hearing and the second that we shall control discharge. Naturally, when the mastoid is infected one has no option but to do the classic endaural operation, but if operation on the mastoid can be avoided, one may, in addition to controlling the discharge, restore hearing.

DR HOWARD P HOUSE. I agree with Dr Tolan that preservation of skin for the purpose of lining the cavity may help prevent annoying postoperative drainage due to incomplete epithelization. Creation of a small cavity has definite value in the fenestration operation.

I agree with Dr Popper that no "man-made job" is as good as nature's. Certainly, unnecessary removal of noninfected bone is to be avoided, whenever possible.

## MÉNIÈRE'S SYNDROME

Observations on Vitamin Deficiency as the Causative Factor

### I The Vestibular Disturbance

MILES ATKINSON, M D, F R C S (Eng)

NEW YORK

MÉNIÈRE'S syndrome may be regarded as consisting of two phases (1) the acute, the attacks of vertigo or the vestibular disturbance, (2) the chronic, the deafness and tinnitus or the cochlear disturbance, which persists between the acute paroxysms. The present paper is concerned solely with the acute phase. The chronic phase will be dealt with in a subsequent communication.

In earlier papers<sup>1a, b</sup> it was reported that patients with Ménière's syndrome could be divided into two groups by determining the degree of response to an intradermal injection of histamine performed under standard conditions.<sup>2</sup> Clinical experiments were described which showed that in the group which gives a small or negative response the symptoms are improved by vasodilator drugs and made worse by vasoconstrictor drugs, while in the group which gives a large or positive response the reverse is the case. These findings were interpreted as evidence for a vascular mechanism as the basis of the characteristic recurring attacks of vertigo—in the one group (the histamine-negative) a primary vasospasm, and in the other (the histamine-positive) a primary vasodilation—and treatment directed toward overcoming the particular vascular disturbance in each group has proved reasonably satisfactory. These observations led inevitably to the question—what is the factor, or what are the factors which produce these disturbances of vascular function? The purpose of this paper is to put forward clinical evidence in support of the thesis that one such factor, perhaps the essential factor, is a nutritional, more specifically, a vitamin, deficiency.

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Read before the Central New York Eye, Ear, Nose and Throat Society, Rochester, N. Y., April 28, 1948

1 (a) Atkinson, M. Observations on the Etiology and Treatment of Ménière's Syndrome, *J. A. M. A.* **116** 1753 (April 19) 1941, (b) Histamine in the Treatment of Ménière's Syndrome. An Appraisal, *ibid.* **119** 4 (May 2) 1942, (c) Ménière's Syndrome. Results of Treatment with Nicotinic Acid in the Vasoconstrictor Group, *Arch. Otolaryng.* **40** 101 (Aug.) 1944, (d) Ménière's Syndrome. Its Mechanism and Management, *New York State J. Med.* **44** 489 (March 1) 1944.

2 To insure accuracy in judging this test, it is important that there be transverse lighting with a flashlight in a darkened room. In this way a pseudopod will often be seen which with direct lighting is not visible.

## PRELIMINARY OBSERVATIONS

It will make for better understanding of the statistical tables and of the method of treatment to be described later if first a brief account is given of how they came to be arrived at

Since the original papers on the use of nicotinic acid in the treatment of patients with Ménière's syndrome were published,<sup>2a</sup> this substance has come to be widely used, and satisfactory results obtained with it in a large series of cases of the vasoconstrictor group have been reported.<sup>1c</sup> In the past it has been the contention that in this group the effect of nicotinic acid depended solely on the vasodilator action, but the possibility that it was due to a vitamin action has always been present. It will be seen later that in these cases clinical signs of niacin deficiency are actually present.<sup>2b</sup>

Although the results of nicotinic acid therapy in the vasoconstrictor group were in general satisfactory as regards relief of the major attacks of acute rotational vertigo with vomiting, many of these patients continued to experience positional vertigo, manifested by momentary flashes of "dizziness," particularly on sudden movements of the head, or even by longer-lived periods of general unsteadiness. In a few cases, after an initial satisfactory response, attacks seemed to be induced by the continued exhibition of nicotinic acid, and once or twice in the most severe cases an attack undoubtedly has been produced by intravenous injection. The type of attack, however, has been different, and from being originally of the rotational type with vomiting it assumed the character of lateral or vertical movement of objects, now usually without vomiting, though with nausea. In the most severe cases the

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2a Harris, H. E., and Moore, P. M., Jr. The Use of Nicotinic Acid and Thiamin Chloride in the Treatment of Ménière's Syndrome, *M. Clin. North America* **24** 533 (March) 1940. Atkinson.<sup>1a</sup>

2b The word "niacin" is used here as a general term to denote the nicotinic radical. The word was compounded originally from three words, *nicotinic acid vitamin*, and therefore, strictly speaking, should be used only as an alternative for nicotinic acid. Since the advent of nicotinic amide, however, niacin has come to be used as synonymous with both the amide and the acid. This has led to so much confusion that even the term "niacinamide" has been coined. Nutritionists now seldom use nicotinic acid for prevention or treatment of deficiency, preferring nicotinamide because it does not produce what is regarded as the undesirable vasodilator effect associated with nicotinic acid. However, in the treatment of patients with certain clinical conditions, of whom the vasoconstrictor group of patients with Ménière's syndrome is an example, the acid is preferable to the amide precisely because of this effect. As a way out of this difficulty of terminology, the term "niacin" has been used in this article in a generic sense to include both substances, and when one or other of the nicotinic derivatives is specifically intended, it has been referred to as nicotinic acid or nicotinamide. From the clinical, as opposed to the nutritional, point of view the two are not interchangeable (see page 171).

effect was that of a sudden knock-down blow. At the same time as this change in clinical type took place, the results of the histamine skin test changed from negative to positive. Moreover, now that awareness of possible vitamin deficiency had come to consciousness it was observed that these patients presented the signs of riboflavin deficiency in addition to those of niacin deficiency. Riboflavin was therefore administered, and it was found that by this means the new attacks could be controlled.

In addition to the attacks of vertigo many of these patients complained of great fatigue and "weak spells." These had often been present from the beginning in some degree but became more pronounced as nicotinic acid and riboflavin continued to be given, and in addition there arose nervousness, jitteriness and irritability. When thiamine was thereupon added, these symptoms also subsided.

In this way it was found possible by administration of the appropriate vitamin to remove symptoms layer by layer as on a palimpsest. As one layer was removed so, the next became evident. Cases 1 and 2 were the first of several in which the patient was so observed and treated.

CASE 1—The patient, a woman aged 31 years, was first seen in January 1943. She had a typical Ménière's syndrome with associated headache in the frontal and occipital areas on the affected side. The attacks of vertigo had started one year previously, they occurred at first about once a month in the winter only and were of two types. In one type of attack she experienced severe rotational vertigo with vomiting. In the other type the sensation was of lateral movement of objects without vomiting but with severe nausea. In addition, she complained of oozing from both ears, particularly at the time of an attack (this was otitis externa) and of considerable fatigue. The result of the histamine skin test being negative, she was treated with nicotinic acid, which gradually controlled the acute attacks of rotational vertigo with vomiting, but had no effect on the less severe attacks in which objects moved from side to side.

A year later, in January and February 1944, she had three attacks of positional vertigo in six weeks, none of which she called severe, because they were short-lived and she did not vomit, though in the last of these she had for the first time fallen to the ground. The ears had been oozing badly for six days previously. During this six weeks her dose of nicotinic acid had been increased because of the attacks, her husband, a doctor, giving her daily injections in addition to her oral medication. These injections seemed to have increased the frequency of the attacks. In consequence, they were stopped, but the oral dosage was continued at a reduced level. In April 1944 she had one or two mild attacks, but then the attacks ceased and on the lower oral dosage of nicotinic acid she was well until September 1945, when she again had two knock-down attacks and was nervous. She did not return, however, until April 1946, after having had, in the interval, one mild rotatory attack and two more knock-down attacks, the second two days before in a restaurant, where she fell face forward into her soup. Her ears were oozing profusely. At this time a histamine skin test gave a small positive reaction. During all this time she had been taking nicotinic acid in varying dosage, but consistently. To this in



the light of the new concept was now added riboflavin. Three weeks later she reported that she had had one mild attack only and that the ears had stopped oozing.

In October 1946 she reported that she had had no further attacks of either type but that she was extremely nervous and upset, indeed panicky, and complained of fear of heights, of crowds, of the subway and also of extreme fatigue. She was thereupon given thiamine hydrochloride by injection and by mouth in addition to the nicotinic acid and the riboflavin. A month later, in mid-November 1946, she said that she felt "like her old self again for the first time in five years." Since then until last seen in mid-November 1947 she has been treated constantly with oral dosage of nicotinamide, riboflavin and thiamine, has had no attacks, no headache, no undue nervousness, has been through a pregnancy successfully without recurrence of symptoms, and her otitis externa has resolved.

CASE 2—This is another similar case. The patient was a woman, aged 49 years. Nicotinic acid, after at first relieving major attacks of rotational vertigo, which were occurring two or three times a month, later was found to induce attacks, though now they were of a positional type. At the same time the patient became extremely irritable, was at times quite rude when making appointments over the telephone, and on one occasion, after having been kept waiting five minutes before being seen and having paced the waiting room the while, refused to wait any longer and walked out. When later she returned, she was given riboflavin in addition to nicotinic acid, which rapidly controlled the new attacks, and soon thereafter thiamine hydrochloride, a procedure which rapidly turned her from a difficult, uncooperative patient into a pleasant, placid one who returns regularly for a routine check-up. She has now been free from attacks of any sort for twelve months.

Thus it began to appear that the two main types of vertigo of which these patients complain, rotational vertigo, on the one hand, and forced movement or positional vertigo, on the other, are in fact two separate entities, that each is associated with a specific deficiency which can be correlated with the result of the histamine skin test, that, moreover, many patients suffer from both types of vertigo and from both deficiencies.

The obvious next step was to investigate the histamine-positive group from the standpoint of vitamin deficiency, and, as will be seen later, what was to be expected from the findings in the cases described was observed, that in this group the predominant deficiency is of riboflavin and the type of vertigo is positional.

In the light of these findings it became necessary to revise the method of grouping patients according to their response to the histamine skin test. Whereas previously they had been divided into two groups only, those with negative and those with positive results, it now became necessary to introduce a third or intermediate group consisting of those who showed a large response without true pseudopodia (large negative reaction) and those who showed one or more small pseudopodia (small positive reaction) instead of the one or more long, trailing pseudopodia which constitute the true positive response. The remainder of this

paper will describe the observations made in a series of cases of typical Menière's syndrome from the new point of view just outlined

# MATERIAL AND PROCEDURE

*Material*—Eighty-seven consecutive cases of the classic Ménière's syndrome, i e, cases showing the full-fledged triad of acute paroxysmal vertigo, deafness and tinnitus, predominantly or entirely unilateral, have been investigated from the standpoint of deficiency in the three major components of the B complex (niacin, riboflavin and thiamine) during the twenty-one months from March 1946 through November 1947

*Procedure*—The procedure for each patient has been

- 1 To record the response to a standard dose of histamine diphosphate administered intradermally under standard conditions as described elsewhere<sup>1d</sup>
- 2 To note the types of vertigo complained of by each patient
- 3 To keep a chart of those symptoms generally accepted as accompanying certain vitamin deficiencies (chart)

## VITAMIN A

Night blindness  
Hyperkeratosis  
Dental caries

## RIBOFLAVIN—Continued

Corneal vascularization  
Pinguecula

## THIAMINE

Anorexia  
Constipation  
Loss of weight  
Paresthesias  
Muscular tenderness  
Fatigue  
Loss of tendon reflexes  
Palpitations  
Tachycardia  
Cardiac enlargement

## NIACIN

Tongue  
Abdominal tenderness  
Anorexia  
Diarrhea  
Dermatitis  
Mental depression  
Mental confusion  
Loss of memory  
Headache  
Vertigo  
"Feel the cold"

## RIBOFLAVIN

Cheilosis  
Seborrheic dermatitis  
Magenta tongue  
Photophobia  
Lacrimation  
Eye strain

## ASCORBIC ACID

Gums  
Joints  
Hemorrhages  
Weakness

4 To make a corresponding physical examination, noting signs of niacin deficiency in the tongue, of riboflavin deficiency in the eyes, the lips, the skin of the face and in the tongue, of thiamine deficiency in disturbances of function of the nervous system as shown by hyperreflexia or hyporeflexia

5 To record by means of color photographs the appearances of the organs mentioned in the foregoing paragraphs

6 To treat each patient with the particular fraction appropriate to his group and with that alone in the first place and to observe and record the results of such treatment

#### RESULTS OF EXAMINATION

Using as a yardstick for niacin deficiency the criteria laid down by Kruse for the tongue,<sup>3</sup> for riboflavin deficiency the criteria of Kruse and co-workers<sup>4</sup> for the tongue and eyes, and for thiamine deficiency the degree of activity of the patellar tendon reflex, and associating these objective findings with the subjective complaints, an assessment was made in each case of the degree of deficiency of each of what Spies has called the big three of the B complex. Four degrees of deficiency were used in the assessment—1 and 2 plus representing degrees of mild chronic deficiency, and 3 and 4 plus, degrees of severe chronic deficiency.

By these criteria every patient showed evidence of chronic deficiency of these three factors in greater or less degree, while in some, in addition, acute manifestations would be superimposed on the chronic background at a time of attacks and be manifested by such complaints as sore tongue, diarrhea, angular stomatitis, sore eyes, oozing ears (case 1), fatigue, tachycardia and palpitations. Although in many cases deficiency of one factor predominated, evidence of some deficiency of the other two was almost always present, and in some there was more or less equal deficiency of all three (tables 1, 2 and 3). This was to be expected if deficiencies were found at all, since vitamin deficiencies like other troubles seldom come singly.

Further, it was found that the results of the histamine skin test could be correlated with the predominant deficiency.

*Group 1 Patients Whose Reactions to Histamine Were Negative*—The 20 patients of this group—23 per cent of the total number of patients—showed predominant niacin deficiency of the chronic type (table 1). In 16 of the 20 patients the deficiency was severe, while in only 4 was it mild. As against this, riboflavin deficiency in this group was predominantly mild, in 15 of the 20 patients it was of

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3 Kruse, H. D. The Lingual Manifestations of Aniacinosis, with Especial Consideration of the Detection of Early Changes by Biomicroscopy, *Milbank Mem Fund Quart* 20:262 (July) 1942.

4 Kruse, H. D., Sydenstricker, V. P., Sebrell, W. H., and Cleckley, H. M. Ocular Manifestations of Ariboflavinosis, *Pub Health Rep* 55:157 (Jan 26) 1940.

this degree, and in only 5 was it severe and in none of them was it classed as 4 plus. Thiamine deficiency also was mainly mild, 11 of the 13 patients for whom this deficiency was recorded having the mild grade and only 2 the 3 plus grade and none the 4 plus grade.

TABLE 1—*Deficiencies in the Histamine-Negative Group (20 Cases)*

Degree of Deficiency	Cases in Which Given Degree Was Noted		
	Nicotinic Acid	Riboflavin	Thiamine
0	0	0	0
+ } Mild	0 } 4	2 } 15	6 } 11
++ }	4 }	13 }	5 }
+++ } Severe	13 }	5 }	2 }
++++ }	3 }	0 }	0 }
Total	20	20	13 (7 unrecorded)

TABLE 2—*Deficiencies in the Histamine-Positive Group (24 Cases)*

Degree of Deficiency	Cases in Which Given Degree Was Noted		
	Nicotinic Acid	Riboflavin	Thiamine
0	0	0	1
+ } Mild	8 } 24	0 } 7	2 } 10
++ }	16 }	7 }	8 }
+++ } Severe	0 }	11 }	10 }
++++ }	0 }	6 }	0 }
Total	24	24	21 (3 unrecorded)

TABLE 3—*Deficiencies in the Intermediate Group (43 Cases)*

Degree of Deficiency	Cases in Which Given Degree Was Noted		
	Nicotinic Acid	Riboflavin	Thiamine
0	0	0	3
+ } Mild	5 } 18	2 } 16	10 } 25
++ }	13 }	14 }	15 }
+++ } Severe	22 }	21 }	14 }
++++ }	3 }	6 }	0 }
Total	43	43	42 (1 unrecorded)

*Group 2 Patients Whose Reactions to Histamine Were Positive*—The 24 patients—27 per cent of the total number of patients—showed, by contrast, predominant deficiency of riboflavin (table 2). In 17 of the 24 patients the deficiency was severe; in only 7 was it mild, and in these it was 2 plus. Niacin deficiency, on the other hand, appeared mild in every patient. Thiamine deficiency tended to be more severe in this group, 10 of 21 recorded were classed as having

severe deficiency (3 plus) and 10 as having mild deficiency, while 1 showed no objective evidence of thiamine deficiency

*Group 3 An Intermediate Group, Whose Reactions Were of the Large Negative or Small Positive Type*—These 43 patients—50 per cent of the total number—formed the largest group. In this group deficiencies were fairly evenly divided, though as far as concerns nicotinic acid and riboflavin the majority were of severe degree (table 3). Niacin deficiency appeared mild in 18 of the 43 patients and severe in 25. Riboflavin deficiency was mild in 16, severe in 27. Thiamine deficiency tended to be mild, 4 of the 42 recorded had no evidence of deficiency, 25 had a mild degree, and 14 a severe degree, 3 plus only.

Thus the result of the histamine skin test can be translated into terms of niacin or riboflavin deficiency and can be used, and effectively used, as a check on the physical findings. A negative result is associated with a predominating niacin deficiency, a positive result with a predominating riboflavin deficiency, and an intermediate response with fairly evenly mixed deficiencies of both fractions.

TABLE 4—*Types of Vertigo in Groups*

Group	Rotational	Mixed	Positional	Total
Vasoconstrictor (histamine —)	5	14	1	20
Intermediate (histamine $\pm$ )	3	34	6	43
Vasodilator (histamine +)	2	8	14	24
Total	10	56	21	87

#### TYPES OF VERTIGO RELATED TO SPECIFIC DEFICIENCIES

The fact that many patients complain of two different types of vertigo, rotational and positional, that change of predominance of one type over the other may take place under treatment and be accompanied by change of response to histamine intradermally injected, and that it has been possible to control one type with one vitamin and the other with another (cases 1 and 2) suggested, as has been said, that a specific type of vertigo is associated with a specific deficiency. The findings in the present series bear out this assumption (table 4).

In the histamine-negative or predominantly niacin-deficient group 5 of 20 patients described the vertigo as rotational only, 1 as positional only (in this case lateral movement of objects), the remaining 14 experiencing both rotational and positional vertigo. The bare figures, however, do not give the whole story. In all 14 of those experiencing both kinds of attack, the severe attacks were associated with rotational vertigo, while positional vertigo consisted only of momentary "flashes" of imbalance or some unsteadiness between attacks. Thus, in 19 of the

20 patients of the niacin-deficient group the predominant or sole type of vertigo was rotational

By contrast, in the histamine-positive or predominantly riboflavin-deficient group 14 of the 24 patients experienced vertigo of positional type only, 2 described rotational vertigo only, and 8 described attacks of both types with positional vertigo the more severe. Here again the bare figures do not delineate the picture accurately. Positional vertigo was always much more severe than in the previous group, attacks were longer lived, often disabling, associated with severe nausea, though seldom with vomiting, while several patients experienced the most severe degree of positional vertigo, a knock-down blow, even occasionally with momentary unconsciousness. Thus, in this group with a predominating riboflavin deficiency positional vertigo was the sole or the more severe type in 22 of the 24 patients.

In the intermediate or mixed deficiency group vertigo of both types and of varying degrees of severity occurred in 34 of the 43 patients, with only 3 describing rotational vertigo alone, only 6 positional vertigo alone.

It appears from these observations that the type of attack, the result of the histamine skin test and the signs of specific deficiencies can all be tied in together. It is a fascinating exercise to predict from the clinical history the result of the histamine test and the predominating deficiency, and it can be done, after a little practice, with surprising accuracy.

#### THE THERAPEUTIC RESPONSE

The final step was to put the observations recorded in the foregoing sections to the test of therapeutic response by treating members of each group with the appropriate vitamin fraction and so far as possible with that alone, at least until satisfactory evidence of its effect had been obtained. The criterion of effectiveness has been control of attacks. Just as in describing the clinical picture, consideration has been directed entirely toward the type of vertigo experienced, and all mention of the cochlear disturbance deliberately omitted, so control of vertigo has been used as the test of therapeutic response. As was said at the beginning, the acute phase alone is dealt with in this paper, without regard to the chronic background. The cochlear disturbance will be considered in a later communication.

*Group 1 Niacin Deficiency and Negative Reaction to Histamine*—Observations on 17 of the 20 patients of this group are available for report (table 5). All these patients were treated initially with nicotinic acid alone. In every one the attacks were rapidly brought under control, and though, as often happens, minor relapses occurred from time to time, these became increasingly less severe and less frequent until in a few months complete control, even of minor manifestations had been established. All 17 patients have been entirely relieved of vertigo.

of any degree for periods of six months to four years (5 had been under treatment with nicotinic acid before this investigation started, and the observations were included in a previous report<sup>1c</sup>)

The method of treatment was that already described intravenous and intramuscular injection, and coincident oral administration which was continued as maintenance treatment for an indefinite period. The only difference in this series has been that in the early stages doses tended to be higher, whereby more speedy control was obtained, and that, once control had been established, a mixed vitamin capsule was added to maintain vitamin balance.

These results are better than those reported previously in a much larger series.<sup>1c</sup> In that series a number of patients who would now, in the light of the present investigation, be placed in the intermediate group, were classified then as histamine-negative and treated accordingly. A high proportion of successes as regards relief of major rotational attacks

TABLE 5—*Results of Treatment with Reference to Control of Attacks of Vertigo*

	Controlled	Improved	Unchanged	Total
Vasoconstrictor group				
Cases—17	17	0	0	17
Deficiency—nicotinic acid				
Intermediate group				
Cases—38				
Deficiency—combined	<div> <div>nicotinic acid</div> <div>riboflavin</div> </div>	<div> <div>5</div> <div>14</div> </div>	<div> <div>0</div> <div>1</div> </div>	<div> <div>36 (see text)</div> <div>38</div> </div>
Vasodilator group				
Cases—18	7	11	0	18
Deficiency—riboflavin				

"Controlled" signifies that the patient has been completely relieved of vertigo but is still under maintenance treatment.

"Improved" signifies that the patient has been freed from major attacks but still has occasional minor experiences of vertigo or unsteadiness.

V<sub>r</sub> means rotational vertigo.

V<sub>p</sub> means positional vertigo.

was obtained, but many had minor residual manifestations of occasional short-lived positional vertigo which they discounted.

The essential point that has been brought out is that the rotational vertigo characteristic of this group can be completely controlled with nicotinic acid alone, that it is, in fact, a manifestation of niacin deficiency.

CASE 3—A woman aged 23 years, first seen on April 25, 1946, had had five attacks of rotational vertigo with vomiting in the previous five years, the last two on April 3 and 5, 1946. Deafness and tinnitus, present at first only at the time of attacks, had been constant since the third attack which occurred in July 1945. She presented marked signs of niacin deficiency in the tongue and gave a true negative response to the histamine skin test. She was given nicotinic acid at first intravenously for two weeks, the daily dose being gradually increased to 50 mg, during which time she had two mild attacks without vomiting. She was then given intramuscular injections, 75 mg being administered daily for another month. During this time she took 150 mg daily by mouth, a dosage which was continued after the intramuscular injections were stopped.

A year later she had had no further attacks. At this time she was told to take a mixed vitamin capsule daily and has not been heard from since.

CASE 4—A man aged 55 years was first seen in November 1945. He complained that he had undergone attacks of rotational vertigo at intervals of three to four months during the previous five years and that there had been deafness and constant tinnitus in the left ear for eight years. The frequency of the attacks had recently increased, four having occurred in the previous two months. He gave a true negative response to the histamine skin test. He was given nicotinic acid. The method of administration was the same as, and the dosage similar to, that in case 3. After the third intravenous injection, his head felt clearer, and the tinnitus started to diminish. Seen in March 1946, when the present investigation began, he was observed to have signs of niacin deficiency in the tongue and mild signs of riboflavin deficiency. He was given a mixed vitamin capsule in addition to his nicotinic acid tablets, which he had been taking steadily, and he has continued this treatment to the present time. In spite of two attacks of influenza, he has had no vertigo since treatment started, and his head is clear except for a bad day about once in six months. He continues his oral medication religiously.

*Group 2 Riboflavin Deficiency and Positive Reaction to Histamine*—Observations on 18 of the 24 patients of this group are available (table 5). Of these, 7 have been completely relieved of their attacks of vertigo, 11 have been improved to the extent that major attacks are under control and minor manifestations, such as occasional periods of unsteadiness or momentary "flashes" of vertigo on sudden movement of the head, are becoming steadily less frequent. The duration of the results extends from six to fifteen months.

It has not been possible to make treatment quite so clearcut in this as in the previous group. In every case riboflavin alone was used initially, and in 9 cases attacks have been controlled completely by its use alone. In the remaining 9, in which it appeared as though control was not being obtained or was inadequate, recourse has been had to the former method of treatment of patients of this group, histamine desensitization,<sup>1d</sup> in addition to the administration of riboflavin, and this proved rapidly effective. The conjunction of the two methods appeared to produce more rapid and more effective control than had been obtained in the past with histamine desensitization alone. The 9 cases in which riboflavin alone failed were all cases encountered in the early stages of this investigation, and failure may well have been due in part to lack of experience and inadequate dosage. As experience has increased and with it intensity of treatment, the results obtained with riboflavin alone have improved and are improving, so that latterly recourse to histamine desensitization has not been found necessary.

With riboflavin a method of treatment has been used similar to that with nicotinic acid. Intravenous injections of riboflavin alone were given initially, in the beginning of the investigation, the dose increasing at first from 3 to 10 mg, given daily or on alternate days, and later from



5 to 15 mg, the injections numbering from 20 to 40, according to the response and control of attacks. At the same time riboflavin has been given by mouth, the dose increasing at first from 20 to 80 mg a day, later from 40 to 160 mg and even 200 mg a day. As in the previous group, when control of attacks seems to have been achieved and the point of the experiment established that such control could be effected by treatment of the preponderating deficiency alone, other vitamins were given as supplementary therapy to preserve vitamin balance.

Of the 9 patients treated with riboflavin alone, 5 have been completely relieved of their attacks of positional vertigo, while the remaining 4 have been relieved of acute attacks and now have only minor attacks, which are becoming progressively less frequent. Of the 9 patients who have had supplementary histamine desensitization, 2 have been completely relieved, the remainder are improved and improving on riboflavin alone, given in increased dose. Though the evidence is not as definite as that for nicotinic acid in the previous group, it suggests rather strongly that the positional vertigo characteristic of this group can be controlled with riboflavin alone, in other words, that positional vertigo is a manifestation of riboflavin deficiency as rotational vertigo is a manifestation of niacin deficiency. This is further borne out by the findings in group 3.

CASE 5—A man aged 62 years, first seen in July 1947, had started to have attacks of vertigo six months previously. The attacks were of gradually increasing frequency until, when seen, he was having as many as three a week. The vertigo was of a positional type with lateral movement of objects and occasional lateral pulsion. He was nauseated in the attacks and on one or two occasions had vomited. Deafness had been noted in the left ear since the onset of vertigo, with occasional tinnitus. He gave a positive response to the histamine skin test and showed signs in the eyes of severe chronic riboflavin deficiency. He was given 10 mg of riboflavin intravenously for eighteen injections. At the same time he took by mouth at first 40 mg of riboflavin a day and later 80 mg a day. On the fourth day after treatment started, he had a severe attack lasting two hours and felt unsteady for three days afterward. After that he had no more attacks, though on three occasions he felt unsteady and "groggy" for half an hour or so. At the end of a month he said that his head felt clearer than it had for months and that he himself in general felt better. He continues free of attacks while taking riboflavin, 120 mg daily, plus a mixed vitamin capsule, indeed, he is so well that he cannot be persuaded to return for reexamination.

CASE 6—The patient, a woman aged 35 years, was first seen in June 1947. She complained that for the past nine years she had suffered from attacks of "dizziness." In these attacks she had continuous unsteadiness for as long as six days at a time with a tendency to walk to the left and with exacerbations, in which any movement of the head would provoke extreme dizziness. During these attacks she was nauseated but never vomited. At first she had free intervals of several months, but by the time she came for consultation the attacks had increased greatly in frequency, so that during the previous six months she had been having one or two a week. These attacks were short lived, lasting half an hour only, but were severe, though without any background of unsteadiness and still without vomiting. She did not suffer from deafness or tinnitus until

January 1947, when she awoke one morning with severe tinnitus of a roaring, booming character and a severe loss of hearing in the left ear, both of which had remained constant since their onset. She had had "sinus" headaches, two or three a year, for the past twenty years. She showed signs of severe chronic riboflavin deficiency, and mild chronic niacin deficiency. She gave a markedly positive response to the histamine skin test.

Treatment was started with riboflavin, given intravenously and by mouth as described in case 5, and except for a mild attack on the fourth day of treatment and an occasional momentary unsteadiness during the next week she had no more positional vertigo. Early in July, however, her left ear began to feel "tight" again, and her tinnitus became slightly louder. As it was thought that this might presage an attack, histamine desensitization was started, and intravenous injection of riboflavin was continued. The desensitization may or may not have been necessary. From that time until the present (five months) she has had no attack of vertigo, only a feeling of fulness in the ear at infrequent intervals. Tinnitus has diminished, deafness remains unchanged. In general, she feels much better, particularly in the past two months since she began taking mixed vitamins in addition to her riboflavin. She was given twenty-two intravenous injections of riboflavin in all, and the dose has been increased to 200 mg a day, taken by mouth, which is producing continuing improvement.

CASE 7—A man aged 33 years was first seen in August 1944 complaining of attacks of positional vertigo which had been increasing in frequency for the past five years. When seen he was having one or two a week with frequent falls and once or twice momentary unconsciousness. They would last from five minutes to an hour and were associated with nausea but never with vomiting. He had mild loss of hearing in the right ear with occasional tinnitus. He gave a positive response to the histamine skin test. A course of histamine desensitization promptly relieved the attacks, with the hearing restored to normal and the tinnitus abolished.

In January 1945 he had a relapse, which was relieved by a second course of histamine desensitization. In February 1947 he returned with a second relapse, of a relatively mild nature, and it was then noted that he showed signs of severe chronic riboflavin deficiency. On this occasion, therefore, instead of histamine desensitization, intravenous and oral administration of riboflavin was carried out as described, and he promptly improved. After four intravenous injections of riboflavin, 10 mg being given in each, his positional vertigo ceased, the sensation of fulness of the ear disappeared, and he said that he felt better than he had for several years. He was given twelve intravenous injections of riboflavin altogether and 80 mg a day by mouth. By April he was symptom free.

In September 1947 he returned, having had a mild relapse after a period of severe nervous strain due to the illness and ultimate death of his wife. His symptoms were again immediately controlled with riboflavin, 10 mg being given intravenously, and amounts increasing to 120 mg orally, each day. Since then he has been well and free from symptoms. He continues taking riboflavin and mixed vitamins.

CASE 8—As the patient was first seen early in January 1948, this case is not included in the present series. It is reported briefly here because it demonstrates rapid control of severe vertigo with riboflavin only. The patient was a man aged 47 years. From 1942 through December 1947 he had experienced about two severe attacks of vertigo a year, accompanied by nausea only. He staggered in the attacks, walked toward the right and was forced to go to bed because movement of the head made him much worse. Before these attacks

he would have loss of hearing and tinnitus in the right ear and a sense of fulness, all of which were relieved by the attack (Lermoyez type) In December 1947 he had four attacks of the same sort, and from Christmas Day to New Year's Day he had daily attacks For one year before this the deafness and the tinnitus of the right ear had been increasing and were not always immediately relieved by the attack, and since December 1947 both had been constant

Previous treatment had been interesting in its effects Up to December 1947 eustachian catheterization had seemed to be effective—"when the ear was opened vertigo ceased, but now they cannot keep it open for more than a few hours at a time" On Dec 24, 1947 he was given nicotinic acid orally for four days and had four attacks (See comment under "Nicotinic Acid vs Nicotinamide," page 170)

When seen he showed no spontaneous signs of disease of the labyrinth, had a 50 per cent loss of hearing in the right ear and definite signs of riboflavin deficiency The histamine skin test gave a positive reaction

Treatment was started with riboflavin, 10 mg being given intravenously and 40 mg by mouth daily After the tenth injection he reported that all vertigo had disappeared, that his ear was clear, that the noises had ceased and that he felt better than he had for months By that time his daily oral dose had been increased to 80 mg Then he had a relapse His daily intravenous dose was stepped up to 20 mg and his daily oral dose gradually to 200 mg, and control was again obtained Usually an injection would "open" his ear and thus relieve his vertigo within half an hour, and this relief would be maintained for several hours One day he came into the office, unsteady and nauseated, an attack having started while he was being driven in An intravenous injection of 20 mg of riboflavin had no effect, so a second injection was given twenty minutes later In fifteen minutes his ear started to "open," and in forty-five minutes he was free from vertigo Oral dosage was then tried as a means of controlling an attack, and on three occasions he has been able to do this by taking 50 mg in one dose by mouth At the time of writing he has had forty-six injections, his threats of attacks are now infrequent and becoming steadily milder, and the trick of control seems to have been learned, at least in this case He states that he feels better than he has since the attacks first started, and there has been a great change for the better in his appearance in two months of treatment

*Group 3 Mixed Deficiencies and Intermediate Reaction to Histamine*—Observations on 38 of the 43 patients of this group are available for report (table 5) All these patients suffered from vertigo of both types, rotational and positional, 2 had undergone section of the eighth nerve before being seen, and their attacks of rotational vertigo had ceased, but positional vertigo continued after operation with undiminished severity in one, recurred with increased severity four years later in the other, one of the earliest patients in this series, and was not controlled by what is now regarded as quite inadequate treatment There are thus 36 patients with rotational vertigo and 38 with positional vertigo By means of mixed therapy, both niacin and riboflavin being given, rotational vertigo has been relieved in 31 and has been improved and is improving in 5, positional vertigo has been relieved in 23, has been improved and is improving in 14 and was unchanged in 1 (the

second of the 2 patients who had undergone section of the eighth nerve) The duration of these results extends over a period of from six to fifteen months

In the early days of this investigation treatment was restricted to individual fractions If the result of the histamine skin test was on the negative side (large negative), the deficiency was assumed to be preponderantly of niacin, and therefore nicotinic acid alone was administered This served in every case to control the rotational vertigo Then riboflavin was added (not substituted), and gradually the positional attacks also would be brought under control Cases 1 and 2 afford examples of this method On the other hand, when the result of the histamine skin test was on the positive side (small positive), the deficiency was assumed to be preponderantly of riboflavin, and therefore riboflavin alone was administered By this means positional vertigo could usually be controlled, but rotational vertigo remained untouched and even became more severe When nicotinic acid was added (not substituted), the rotational vertigo also was brought under control

Some of the patients in this group had been treated with nicotinic acid before the present investigation started, and their rotational vertigo had been controlled thereby, but they continued to have momentary positional vertigo Others returned in relapse, but now with attacks of positional type, a change on which they would sometimes comment themselves, saying, "These attacks are different There is no spin, and I don't vomit any more" These new attacks were always rapidly controlled by the addition of riboflavin

Thus the results of using individual fractions *seriatim* in this mixed group have agreed with the results observed in the previous two groups, in which the result of the histamine skin test was either definitely negative or definitely positive, and in each of which one variety of vertigo dominated the clinical picture Each variety could be abolished by use of the appropriate vitamin fraction As it became clear that this intermediate group did undoubtedly consist of patients having a more or less evenly distributed mixed deficiency, the members of it began to be treated with both fractions simultaneously, with the result that both types of vertigo could be controlled at the same time Intravenous injections of a mixture of riboflavin and nicotinic acid or nicotinamide have been given, as already described, supplemented with oral administration, the proportion of each fraction varying according to the clinical picture, the physical signs and the result of the histamine skin test By this means more rapid and more effective control has been achieved

CASE 9—The patient, a woman aged 59 years, was first seen in April 1947 From 1934 to 1944 she had experienced at intervals of twelve months or so severe attacks of rotational vertigo with vomiting, both room and bed seeming

to spin to the left or sometimes to roll over backward. In 1944 the character of the attacks changed and they became more frequent. In these later attacks the floor seemed to fall away, and on two occasions she was thrown out of a chair. There was no nausea or vomiting with these attacks. In addition she had frequent flashes of vertigo daily and short-lived waves of unsteadiness. There was considerable loss of hearing in the left ear (35 per cent) with hyperacusis, so that music, voices and loud noises distressed her greatly. In this ear tinnitus had been present off and on for fifteen years but latterly had become constant and was at times so intense that she said it could not have been endured for long at that intensity. In 1940 she had been given histamine intravenously, and thereafter she had an interval of two years free from attacks. In August 1945 she again was given histamine intravenously, and by October her symptoms were bad again. The treatment was repeated, and she was free until February 1947, when a third course of intravenous injections of histamine failed to have any effect. She was then given injections of nicotinic acid, both by vein and by muscle, with considerable flushing reaction and no noticeable improvement. When seen she had been having frequent severe attacks of positional type, in one of which she fell, and she showed signs of severe chronic deficiency of niacin, riboflavin and thiamine. The histamine skin test gave an intermediate response. A course of intravenous injections was started, the doses being gradually increased until by the eighth injection she was receiving nicotinic acid, 40 mg, nicotinamide, 400 mg, riboflavin, 10 mg, thiamine hydrochloride, 100 mg. This dosage was given daily for ten days and then on alternate days for three months, by which time she had had fifty-three injections in all. In mid-August she reported that she had had two mild "flashes" in July and none since. She had had no tinnitus for four of the previous six weeks, and the hearing of the left ear had returned to normal except for the three highest tones. During all this time she was daily taking supplementary vitamins by mouth, viz nicotinamide, 800 mg, riboflavin, 80 mg, thiamine hydrochloride, 160 mg. This improvement has continued. On Dec 1, 1947 she had had no vertigo of any kind since July. She was continuing religiously with her oral therapy and adding an occasional intravenous injection when she felt a little "let down."

#### THIAMINE DEFICIENCY

In addition to the well recognized symptoms of Meniere's syndrome, symptoms generally accepted as being produced by thiamine deficiency are frequently encountered (tables 1, 2 and 3). Of these the most usual are excessive fatigue, "weak spells" and nervousness. These can be abolished by the exhibition of thiamine (cases 1 and 2). It has therefore become routine to add thiamine to the other fractions in all cases, both by injection and by mouth. Not only does this relieve specific symptoms, it also seems to potentiate the action of the other fractions, as was pointed out by Harris and Moore<sup>21</sup> in 1940 with respect to nicotinic acid as used in the treatment of Meniere's syndrome.

The dosage of thiamine varies according to the individual case but must in general be high as is the case with the other fractions. By injection thiamine hydrochloride has been given in doses of from 25 to 150 mg daily, orally it has been taken in amounts of from 40 to 400 mg.

daily In a few exceptional cases even as much as 800 mg, taken daily by mouth, has been necessary for a time to gain control of symptoms

#### DOSAGE AND OVERDOSAGE

It will be noticed that the doses used to obtain the results described in this article are considerably larger than those usually advocated even for therapeutic purposes They have been arrived at as the result of experience When this investigation started, much smaller doses, in line with those generally accepted, were used, but it was soon found that while a few patients responded to such doses, most did not or did not satisfactorily Gradually, therefore, the doses administered both parenterally and by mouth came to be increased, and this tendency toward larger doses continues

A warning is necessary with regard to high dosage—it must be arrived at gradually If large doses are given immediately or arrived at too rapidly, symptoms may be temporarily increased and attacks provoked This applies particularly to cases of severe chronic deficiency The longer the attacks have been in existence and the more severe the signs of chronic deficiency, the more gradual must be the increase, but the higher it may eventually need to be and the longer it will need to be continued if relapses are to be prevented In any event control is not to be expected immediately, and occasional relapse in the early days of treatment is to be anticipated Of both these eventualities patients should be warned at the outset The most that can be offered is a gradual diminution of the frequency and the severity of attacks, and relapse is to be regarded by both patient and physician as an indication for more intensive treatment, not for a throwing up of hands in despair Treatment of this condition demands patience and persistence on the part of both patient and physician There are no miraculous cures, and in cases of long standing progress may be discouragingly slow A patient of 63, with a bald tongue, was under treatment with nicotinic acid and thiamine or five years before her major rotational attacks were brought under complete control, and she has now had none for two years She continued to have minor positional attacks with periods of headache, distressing tinnitus and general ill health These have only been reasonably controlled, and still not completely, after two years of added riboflavin and mixed vitamins In the cases which are not of such long standing in terms of age of patient and duration of symptoms, with more or less acute signs imposed on a mild chronic background, the disease is more rapidly controlled and with smaller doses, but even in these cases no dramatic recovery may be expected, though occasionally one occurs

The method adopted has been to start with small doses parenterally and orally and to increase the doses slowly until the acute symptoms

the attacks, are controlled. It has been found inadvisable to begin with a large dose as is usually done in treating the acute stage of a nutritional disorder, owing to the possibility, already mentioned, of increasing symptoms temporarily. This is the more to be avoided because many of these patients display considerable anxiety, particularly those who have been treated by various methods for long periods without success, and to increase symptoms severely in the early stages of treatment is to invite loss of confidence.

Once control has been firmly achieved, parenteral administration can be omitted, but oral dosage must be maintained for months and years if recurrences are ultimately to be prevented. Relapse demands increase of dose and preferably a temporary return to parenteral administration. It must be insisted that there is no specific adequate dose of any or all of the fractions for all patients. The level and the proportions must be tailored to fit the needs of the individual patient, and in the mixed cases a careful balance of all fractions must be kept.

The estimate of adequate dosage must depend on clinical acumen and experience. When the maintenance oral dose appropriate to the individual patient has eventually been arrived at, it must be continued, as cautioned in a previous paragraph, for month after month, year after year. Such long-continued administration is necessary because what has to be done is to repair damaged tissue, and the rebuilding of tissue can obviously come about only slowly. Indeed, some degree of irreversible change may have taken place, and it may well turn out, therefore, that some patients must continue to take small doses of vitamin supplements for the rest of their lives in order to insure the best possible functioning of such tissue as remains.

#### COMMENT

*The Clinical Picture*—That the clinical picture of Ménière's syndrome is more complex than it is generally considered to be was first suggested by the observation of Lermoyez<sup>5</sup> who as long ago as 1919 described a group of cases characterized by deafness and tinnitus which accompanied vertigo and which were relieved or improved by it—"le vertigo qui fait entendre" (the vertigo which restores hearing)—in contrast to the more usual variety in which deafness and tinnitus precede the attacks of vertigo and are made worse by them. The validity of this observation was reinforced by observations that the two groups could be differentiated by their different response to the intradermal injection of histamine, that they presented different clinical pictures and that the Lermoyez picture was comprised in the histamine-

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5 Lermoyez, M. Le vertige qui fait entendre, *Presse med* 27 1, 1919

positive group The present investigation has carried the clinical differentiation of the groups still further

There are two distinct and characteristic types of disturbance In one the deafness and tinnitus appear gradually, precede the onset of vertigo even by many years and are increased by the attack, and the vertigo is of rotational type, usually accompanied by vomiting and often by diarrhea This group gives a small response to an intradermal injection of histamine, has a primary vasoconstrictor mechanism and presents predominantly the signs of niacin deficiency In the other the deafness and tinnitus appear at the time of the first attack of vertigo, are abolished by the attack in the beginning, though in the course of time there remains a gradually increasing residuum, and the vertigo is of the positional type, accompanied by nausea though seldom by vomiting This group gives a large response to an intradermal injection of histamine, with pseudopodia, has a primary vasodilator mechanism and presents predominantly the signs of riboflavin deficiency One common variant of the clinical picture in this group is seen in the patients in whom deafness and tinnitus arise abruptly and severely with the first attack of vertigo and are unrelieved by it—in whom loss of hearing of the affected ear may even be complete and permanent These are the patients who go to bed hearing, awake in the morning deaf, with roaring tinnitus, get out of bed and fall to the floor The other variant is seen in the patients in whom vertigo precedes the onset of deafness, sometimes by years, a variant which has been given the unfortunate label of "pseudo-Meniere's disease" The symptoms of these patients correspond closely with those described recently by Kuilman<sup>6</sup> and de Raadt<sup>7</sup> as having occurred among prisoners of war in Batavia and ascribed by them to riboflavin deficiency Positional vertigo was the characteristic feature, impairment of hearing was unusual Stannus<sup>8</sup> has described a similar syndrome which he believes to be due to riboflavin deficiency

Thus it becomes more and more apparent that there are two distinct types of clinical picture comprised by the term Ménière's syndrome Moreover, evidence begins to accumulate that both are due to vitamin deficiencies—each to a different one The first is a simple picture due to niacin deficiency, the second, a more complicated one, is due to riboflavin deficiency What has made for confusion is that both pictures are frequently combined in the same patient, which

<sup>6</sup> Kuilman, J Camp Vertigo, *Nederl tijdschr v geneesk* **90** 983 (Aug 17) 1946

<sup>7</sup> de Raadt, O L E Pellagra in the Oto-Neurology and Rhino-Laryngology, Leiden, Universitaire Pers Leiden, 1947

<sup>8</sup> Stannus, H S Disorders of the Nervous System Due to Malnutrition *Brit M J* **1** 342 (Feb 21) 1948



is entirely understandable if the theory of Menière's syndrome as a deficiency disease is correct, since vitamin deficiencies, seldom, if ever, appear singly. These findings explain why no one therapy is effective in every case and why one form of treatment is seldom completely effective in any.

*Nicotinic Acid vs Nicotinamide*—Nicotinic acid has proved successful in the treatment of the vasoconstrictor group. It was originally selected because of its vasodilator effect, but the possibility of its exerting a vitamin action has always been present. This possibility, however, seemed to be ruled out because of the apparent ineffectiveness of nicotinamide in controlling attacks in this group. The ineffectiveness is quite comprehensible if the disturbance is a purely vascular one, incomprehensible if it is due purely to a deficiency, since the amide should then be as efficacious as the acid. The explanation of the apparent anomaly is that both conditions obtain. The mechanism of the attack in this group is a vasospasm, but the cause of the vasospasm is a vitamin deficiency. Thus nicotinic acid produces more satisfactory results in the vasoconstrictor group than the amide because it combines both functions, that of vasodilator and that of vitamin.

Actually it is possible sometimes to control attacks with nicotinamide. Four patients belonging to the vasoconstrictor group have been treated successfully with nicotinamide alone, but they required more prolonged and more intensive treatment and much larger doses to obtain control than have ever been found necessary with the acid. Failure to appreciate this has been the reason for failure to obtain control with the amide in the past.

For instance, a woman aged 52 years, who complained of moderately severe attacks, occurring once every two or three weeks for a year only, was treated throughout with the amide. She required forty-seven intravenous injections of 400 to 600 mg. each of the amide over a period of four months, given daily at first, then three a week and finally two a week, before satisfactory control was established. At the same time she took 800 to 1,600 mg. by mouth daily. Under these dosages she had two mild attacks only in the final two months of the injection treatment and has been kept free of attacks with oral medication but requires 1,600 mg. of nicotinamide daily to prevent relapse. This is a large dose. Experience with nicotinic acid has been that the requirement of an intravenous dose of as much as 100 mg. is rare, the average control dose ranging around 75 mg. intravenously and 400 mg. orally.

Thus, while it is possible to establish control with the amide, the process is much slower than with the acid, requires a considerably higher level of doses and is much more expensive. Some patients who have previously received the acid and subsequently been given the amide

ask to return to the acid because they feel much better with it. One such patient who had been treated previously and successfully with 50 mg of acid intravenously and 200 mg orally daily had failed to keep up his oral maintenance dose and returned in relapse. He was given the amide instead of the acid, but after four daily doses of 200 mg intravenously and 800 mg orally he asked for his "old" medicine again, as he had felt so much better with it than with the amide.

Once control has been established with the acid it can frequently be maintained with the amide if desired. Even so, the vasodilator effect of the acid is preferable until all vasoconstrictor disturbance has been overcome. This change can be determined by the histamine response, which changes from the small to the intermediate appearance.

What has been said in the preceding paragraphs applies to the vasoconstrictor or histamine-insensitive group. In the vasodilator or histamine-sensitive group, however, and in those members of the intermediate group which veer toward the histamine-sensitive end of the scale, the amide is mandatory in the treatment of the niacin deficiency. It has been a repeated experience, and one should emphasize it again, that if members of the vasodilator group are given nicotinic acid they are made worse as regards both frequency and severity of attacks. To give one dramatic example out of many less dramatic, a member of this group was on one occasion given by mistake nicotinic acid intravenously instead of histamine subcutaneously. Fifteen minutes later she had an attack which threw her violently to the ground in the worst attack she had ever experienced, luckily without serious injury. It cannot be too strongly insisted that nicotinic acid with its vasodilator action is poison to the vasodilator group. For the treatment of niacin deficiency in this group the amide, and the amide only, must be used because it has no vasodilator effect.

*Riboflavin and Histamine*—What is the connection between riboflavin and histamine? That there must be some connection seems certain from the consistency with which riboflavin deficiency is found in association with a positive response to injected histamine and from the fact that either substance will relieve symptoms in this group. What the connection may be is at present not known. Zeller and his co-workers<sup>9</sup> have reported that histaminase is a flavoprotein, though other workers<sup>10</sup> have contradicted this. If it were so, it might account for the beneficial action of histamine in riboflavin-deficient subjects by encouraging the production of histaminase. Against this possibility is

9 Zeller, E. A., Stern, R., and Wenk, M. Ueber die Diamin-Diamin-Oxydase Reaktion. VI. Mitteilung über den enzymatischen Abbau von Poly-aminem, *Helv. chim. acta* **23**, 3, 1940.

10 LeLoir, L. F., and Green, D. E. Histamine Oxidase, *Federation Proc.* **5**, 144 (Feb.) 1946.

the fact that commercially available histaminase has proved completely ineffective in treatment

Whatever the explanation, the clinical fact remains that the histamine-sensitive patients show signs of riboflavin deficiency and can be relieved temporarily by the administration of either histamine or riboflavin. It is hoped that the prolonged use of riboflavin will ultimately give permanent relief in this group, in the same degree that nicotinic acid does in the vasoconstrictor group, but the patients have as yet not been observed long enough to establish this. What has been established is that attacks can be controlled with riboflavin if this is administered in suitable dosage. Two patients not included in this series, one a physician, have on several occasions staved off what they knew would have been severe attacks with a large dose of riboflavin.

*Dietary vs Nutritional Deficiency*—This concept, that Ménière's syndrome is a nutritional disturbance, may be objected to on the grounds that the subjects of Meniere's syndrome as seen in everyday practice do not, in most cases, subsist on a frankly inadequate diet. However, if a careful dietary history is taken, it will usually be found that their dietary habits are bad and that their present diet is unbalanced, lacking in important foods, such as milk, and all too frequently improperly prepared. This has been pointed out by Selfridge<sup>11</sup>. Moreover, not infrequently their childhood feeding has been inadequate as the result of economic or cultural factors. Because of this and of other later incidents which have interfered with nutrition, such as a severe illness, alcoholism or gastrointestinal disturbances interfering with adequate absorption, there has been built up over the years a condition of chronic nutritional deficiency which is too severe to be corrected by diet alone no matter how adequate that diet may be. It is this chronic background which is exhibited by the patients with Ménière's syndrome.

The story, then, is this. For one reason or another a state of chronic nutritional deficiency arises which is continuously increased by the stresses and strains of living. Eventually comes a time when the subject is teetering on the edge of a nutritional precipice, conscious perhaps of vague ill health, though without the symptoms of a defined disease, until one day some perhaps trivial incident, a cold, a tooth extraction, a minor accident, topples him over into the abyss of an acute deficiency with full-blown overt, even catastrophic, symptoms. He now has an acute deficiency imposed on his background of chronic deficiency. If the picture is one which is recognized as nutritional in origin, such as pellagra, he will be treated accordingly and his acute symptoms will disappear. But unless the chronic background is also treated over a long period, his acute symptoms will recur as a result of smaller and smaller insults and,

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<sup>11</sup> Selfridge, G. Meniere's Symptom Complex. Its Relation to Chemistry, Arch Otolaryng 49 1 (Jan) 1949

therefore, at shorter and shorter intervals, in fact at any time when he is subjected to undue stress. It is the failure to treat adequately, or at all, the chronic background which accounts for the notorious tendency of nutritional diseases to relapse.

If the classic picture of Ménière's syndrome is considered in this light, it will be seen that it conforms with the picture of a nutritional disorder. Usually the first evidence of trouble observed by the patient is the gradual onset of deafness with tinnitus, though, if he be closely questioned, he will often admit that he was conscious at this time, or even before he was aware of any cochlear disturbance, of a state of health below normal—he tired easily, he was lacking in ambition, he was nervous and irritable, his digestion was not as good as it should have been. Then one day he "caught a cold" or had an attack of "grip" and immediately thereafter he had his first attack of vertigo. How often that or some similar story is told and how often it is disregarded! The attack of vertigo puts him to bed, forces him to give up work for a time or to take life more easily and he builds up a small reserve again. When that reserve is exhausted—how soon depends on the degree of his deficiency, on the degree of impairment of function of his tissues—comes another attack, another acute breakdown. So the disease goes on in the familiar cycle of remission and relapse, with increasing frequency of attacks, increasing evidence of impairment of general and cochlear health, with increasingly severe chronic deficiency. When on top of this are imposed well intentioned but ill advised dietary restrictions the result may be disastrous. Such a case has been investigated recently. A man in whom attacks had increased up to two or three a week was admitted to a hospital where he was fed a severely restricted diet, with the result that he lost 30 pounds (14 Kg) in six weeks. Attacks gradually increased during this time until he was having three or four a day, was constantly unsteady and was alarmingly ill. Intensive vitamin therapy controlled the attacks in a week, and at the time of writing he has been without further attacks for five weeks, has regained his sense of balance, is putting on weight and looks and feels like a different person. Such improvement in general health is a fairly constant happening in cases in which the patient is under adequate nutritional therapy and one on which the patient is often the first to comment.

#### SUMMARY

The present investigation has brought out the following points

1. Subjects of Ménière's syndrome experience two distinct types of vertigo, rotational and positional, which have been found to be associated with different and specific vitamin deficiencies.

2 Those patients who experience rotational vertigo alone, show signs of nicotinic acid deficiency in the tongue, give a small response to histamine injected intradermally and can be relieved of their attacks with nicotinic acid

3 Those patients who experience positional vertigo alone, show signs of riboflavin deficiency in the tongue, the eyes and the skin, give a large response to histamine injected intradermally and can be relieved of their attacks with riboflavin

4 Those patients, the majority, who experience both kinds of vertigo, show signs of a deficiency of both fractions, give an intermediate response to histamine injected intradermally and can be relieved of their attacks only if both fractions are exhibited

5 Other symptoms common in patients with Ménière's syndrome can be related to other deficiencies, such as the fatigue, irritability and palpitations associated with thiamine deficiency, and can be relieved by administration of the appropriate vitamin

6 Successful therapeutic results depend on a method of treatment and a level of dosage such as have been described

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## ESOPHAGEAL VARICES IN BANTI'S DISEASE

Report of Two Cases in Which the Condition Was Improved with  
Injection of Sclerosing Solutions

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ANY UNDERSTANDING of the problem of esophageal varices requires some knowledge of the anatomy of the portal vein and its collateral veins. It is because of the gradual occlusion of this vein and the forced development of the collateral system that these varices occur.

The portal vein which courses through the liver represents a confluence of the superior mesenteric vein, the inferior mesenteric vein, the splenic vein and the coronary, cystic and parumbilical veins and their tributaries. The portal system may be defined to include all the veins that drain the abdominal portion of the digestive tube.

The cause of the esophageal varices is the same as that of some varices elsewhere in the body, e g, hemorrhoids, rests in the mechanical obstruction of the portal vein. Any of a series of possible causes which would effect a gradual closure of this venous system and which permitted time for the development of the collateral system might thus be the responsible factor.

The collateral circulation that develops could not do so but for preexisting communications. These are between the gastric and the esophageal veins, the veins of the colon and the duodenum and the left renal vein (the so-called accessory portal system of Sappey—in which branches pass around the falciform ligament to unite with epigastric and internal mammary veins). There is also a large single vein, the parumbilical, which may pass from the hilus of the liver to the umbilicus (When this functions it produces the well known caput medusae.) The third is that of veins of Retzius, which may connect the intestinal

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veins with the inferior vena cava and its retroperitoneal branches, the fourth and last channel of communication is between the inferior mesenteric vein and the hemorrhoidal veins. These open into the hypogastric vein.

As indicated by the expression "gradual occlusion of the portal system," the chief causes of chronic and long term portal obstruction rest within the group of pathologic conditions known as cirrhosis of the liver. All types of cirrhosis of the liver have one feature in common, an increase in the connective tissue of that organ. When and if this connective tissue is in a position to restrict the return flow of blood of the portal system, the opportunity for the setting up of the collateral venous drainage is created.

In the cases to be reported one is especially concerned with Banti's disease, known also as splenic anemia. This is a chronic disease of unknown origin and cause. The origin has been described by some vaguely as toxic and primary in the spleen and by more modern authors as primary in the liver. It is characterized by splenomegaly, anemia, leukopenia and a "tendency to gastric hemorrhages." The later stages of the disease are characterized by cirrhosis of the liver, jaundice and ascites. The term "Banti's disease" is usually reserved for the late stage when the cirrhotic elements have supervened. This condition is usually considered a disease entity. By some it is considered a syndrome.

Banti divided the disease into three period phases. The first phase is described as the anemic phase, the second as the intermediary and the third as the cirrhotic. The first stage usually lasts for two or more years. The second stage lasts for a few months and the third to the end, usually to terminate with an intercurrent infection or a hemorrhage.

Primary treatment is exclusively surgical. It is splenectomy. This results on occasion in complete relief, in some cases, in marked relief. Recently, anastomosis of the splenic and the left renal vein, combined with nephrectomy, has been performed to create a bypass. Secondary treatment is palliative and supportive. Transfusion and abdominal paracentesis may be required in the cirrhotic stage.

Other cirrroses should be mentioned. These may be classified into three general groups: (1) toxic cirrroses (the most important of which is alcoholic), (2) cirrroses from chronic congestion of the hepatic blood vessels, as in chronic failing or noncompetent right side of the heart, (3) cirrhosis from chronic obstruction of the bile ducts (this group would include, in addition to Banti's disease, syphilitic cirrhosis and the hypertrophic cirrhosis of Hanot). In rare instances cirrhosis due to malaria has been reported.

The reports of Kirklin and Moersch,<sup>1</sup> Moersch<sup>2</sup> and Wolf<sup>3</sup> represent the most extensive pioneering work that has been done on the subject of the sclerosing treatment of esophageal varices. The first report in the Moersch series and the first case reported in this country presents a patient with a past history of hematemesis and melena of several years' duration. Examination of the patient revealed an enlarged

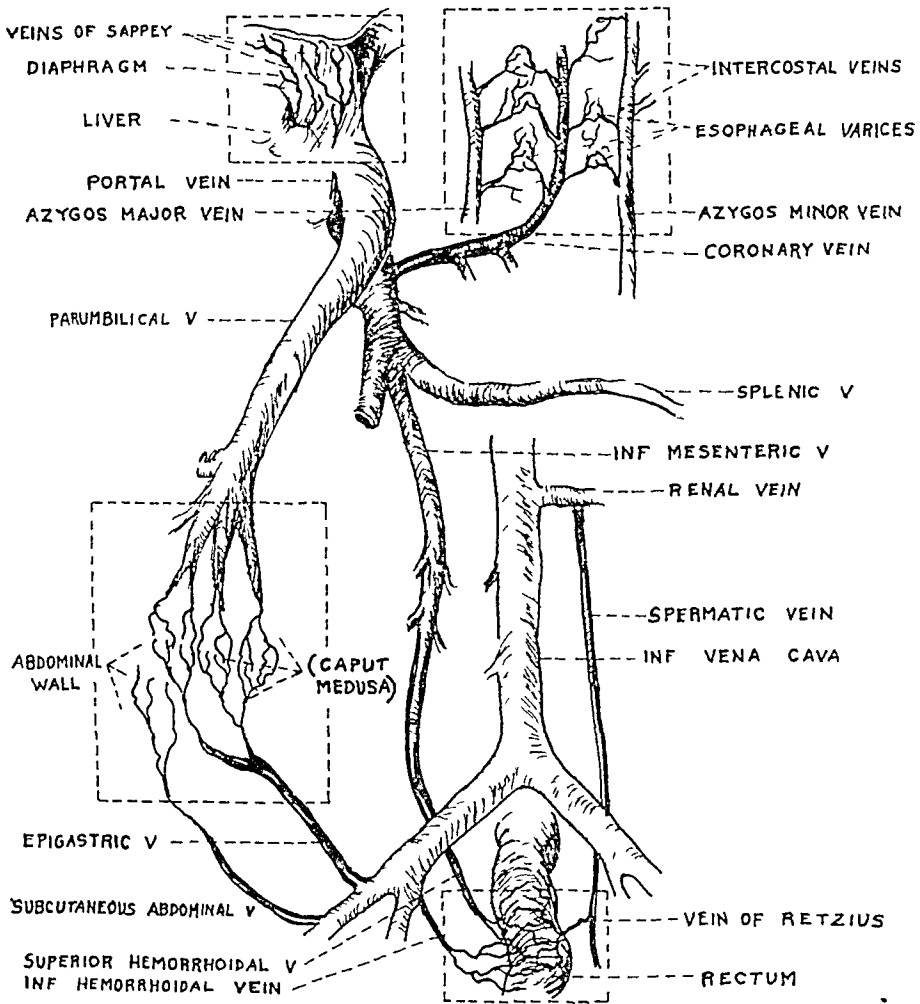


Fig 1—The portal circulation with collateral shunts (after Moersch)<sup>2</sup>

spleen and secondary anemia. On roentgenologic study of the esophagus it was noted that the lumen appeared, at a point just below the

<sup>1</sup> Kirklin, B. R., and Moersch, H. J. Report of a Case of Roentgenologically Demonstrable Esophageal Varices Complicating Splenomegaly, *Radiology* **17** 573 (Sept) 1931.

<sup>2</sup> Moersch, H. J. Treatment of Esophageal Varices by Injection of Sclerosing Solution, *J Thoracic Surg* **10** 300 (Feb) 1941.

<sup>3</sup> Wolf, G. Die Erkennung von Oesophagus-Varizen im Röntgenbilde, *Fortschr a d Geb d Röntgenstrahlen* **37** 890 (June) 1928.



aortic arch, to be a narrow and tortuous canal with marginal defections. These defections were a group of multiple intrusions, and when barium sulfate mixtures infiltrated between them they depicted a lumen of normal width. The diagnosis was thus accurately established with this and endoscopic observation.

In his second report Moersch<sup>2</sup> stated that he had treated esophageal varices by injecting a sclerosing solution. In this report is the first record of such work in this country. Also included is a reference to the earliest known diagnosis of esophageal varix, the report of Power in 1839. Moersch stated that these varices are not too uncommon. They occurred in 5 per cent of 688 patients who came to the Mayo Clinic complaining of hematemesis. In this group of cases of varicose veins Banti's disease was the most frequent cause.

In a later report Moersch<sup>4</sup> recorded the treatment of 10 additional patients. These were usually treated with the sclerosing solution after splenectomy, as splenectomy was considered essential to any prospect of cure of the disease, this because, among other results, the removal of the spleen, if effective, reduces by 20 per cent the amount of blood that passes through the portal system. Moersch has injected as much as 9 cc. into patients without ill effect. He stated that the injection may be accompanied by moderate to severe pain. The whole group of patients, on later canvassing, reported that their condition, was much improved and that they had no more bleeding. The Moersch technic was to inject 0.5 cc. of a 2.5 per cent sodium morrhuate solution by way of an esophagoscope and long 25 caliber needle. The latter necessarily has a length greater than the scope. Injections were usually done partially and at intervals of three to four days.

Welt and Blatteis<sup>5</sup> reported a case in which they used a sclerosing solution. Their patient had been operated on previously for appendicitis and had had a stormy postoperative course. As a result (perhaps of adhesions), the patient had six subsequent operations. After hematemesis and tarry stools had occurred, the presence of esophageal varices was suspected. This was verified with roentgenologic studies. Bleeding was so severe that the patient had required seven transfusions. At esophagosopic examination the lumen was seen to be two thirds obstructed near the base by enlarged veins. The largest of these were at 12 and 6 o'clock. Two cubic centimeters of a solution of sodium morrhuate was injected. Further observation revealed great shrinkage of the varices and no further bleeding.

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4 Moersch, H. J. Further Studies on the Treatment of Esophageal Varices by the Injection of Sclerosing Solution, *Ann Otol, Rhin & Laryng* 50 1233 (Dec) 1941.

5 Welt, B., and Blatteis, S. R. Esophageal Varices. Case Report, *Am J Surg* 63 415 (March) 1944.

Proper control of esophageal varices is absolutely essential. Fatal bleeding can and does occur. One such case was reported in the *New England Medical Journal*<sup>6</sup> of July 1945, another was reported from Australia by Duffly and Fraser<sup>7</sup> in March 1944.

The only other past attempts at therapeutic control of this problem that had any success were of a more difficult and arduous type. One case was reported in which the coronary vein was ligated and retrograde injection of a sclerosing solution was done by a trans-abdominal approach. The retrograde flow of the solution occluded the esophageal veins.

The most recent report on this subject in the literature is that of Patterson and Rouse.<sup>8</sup> They included in their report the histories of 8 patients of a total of 12 whom they had treated for this condition. The youngest was aged 3 and the oldest 66. A total of three to four injections was usually employed, and the intervals between "sittings" varied from a week to a year. One patient received injection before and after splenectomy, 4, after splenectomy, 7, before splenectomy. There were two fatalities in their series, both were from hemorrhage, and one of these occurred some time after the procedure.

Herein is reported for the record the histories of 2 patients treated by the method of Moersch with recovery.

#### REPORT OF CASES

CASE 1—R. G., a white man aged 23, was inducted into the military service and was shipped to the Southwest Pacific theater. He remained there and in good health until April 1944, when he had chills and fever. A series of smears of the blood were studied for malaria but were all negative. During the period of hospitalization he had two episodes of vomiting. Each time he lost about a half cup of dark blood. Shortly after hospitalization an enlarged spleen was noted. He remained hospitalized and was sent back to the United States, where he was admitted to Vaughan General Hospital for definitive treatment. A diagnosis of Banti's disease was made. On Dec 5, 1944 splenectomy was performed. After surgical recovery he was discharged from the hospital. He remained in fair health until May 15, 1946. At this time he became nauseated and vomited a pint of blood. That night he fainted. As a result of this acute episode he was admitted to the Veterans Administration Hospital at Hines, Ill.

At admission the physical examination revealed a well developed and well nourished white man moderately ill. The positive physical findings otherwise were grade II systolic murmur over the precordium and a scar over the left upper quadrant of the abdomen. The red blood cell count was 2,350,000 and the white

6 Portal Cirrhosis and Rupture of Esophageal and Gastric Veins, Cabot Case 3128, *New England J Med* **233** 48 (July 12) 1945.

7 Duffly, D. G., and Fraser, A. N. Fatal Bleeding from Varicosities, *M. J. Australia* **1** 202 (March 4) 1944.

8 Patterson, C. O., and Rouse, M. O. The Injection Treatment of Esophageal Varices, *J. A. M. A.* **130** 384 (Feb 16) 1946.

cell count 14,800, the hemoglobin content was 51 per cent. After a short period of hospitalization the red blood cell count rose somewhat. It was suggested that he was bleeding from esophageal varices, and it was decided to perform an esophagoscopic examination. This was done on June 29. Varicose veins were visualized, most marked at the cardiac end of the esophagus. Esophagoscopic examination was again performed, October 8, and a 2.5 per cent sodium morrhuate solution was injected into the varices. Esophagoscopic examination was repeated on December 6, and the previously treated varices were found to be flattened. On December 7 endoscopic examination was again performed and the sclerosing solution injected into varices in the anterior wall. The varices seemed to have less volume than



Fig 2—Oblique roentgenographic view of the chest demonstrating a defect of the esophagus caused by the intrusion of a varix (indicated by an arrow)

before. After a period of no hemorrhage the patient was discharged to his home. A follow-up letter brought the reply that he has had no symptoms of the varices in the three months since his discharge. He has had no tarry stools, no vomiting of blood, no red blood in the stools, no difficulty in swallowing. He has been working part time.

CASE 2—R. Mc., a white man aged 38, was admitted to the Veterans Administration Hospital at Hines, Ill., in 1941, with a condition diagnosed as Banti's disease. His occupation was that of truck driver. His habits included consumption of

moderate amounts of alcoholic beverages and tobacco There was a previous history of syphilis and gonorrhea He had been given a similar diagnosis in the past and had undergone splenectomy He was discharged after a short period of hospitalization and readmitted in June 1946 because of bleeding believed to be from esophageal varices

The positive physical findings at the time of admission were a soft systolic murmur over the apex and a midline scar There was rather marked pallor Repeated counts of the red blood cells revealed usually 3,000,000 Whenever the level reached 3,300,000 he bled

The interim history revealed that he had had his first bleeding in the fall of 1937 and that he had been hospitalized more than 10 times Roentgenographic studies revealed a slight irregularity of the lumen of the esophagus at its lower end The roentgenologic diagnosis was esophageal varix, it was confirmed by endoscopic examination

The diagnosis was confused at first by not finding any varices on endoscopic examination, Oct 25, 1946 However, this procedure was repeated, and on October 22 two varices were found and a sclerosing solution was injected One of these was half way down the esophageal wall at 12 o'clock, the other near the cardia The procedure was repeated on November 5 and a sclerosing solution injected into a varix just above the cardiac rosette at 5 o'clock From the second injection severe pain resulted, which required morphine for several days After this second injection he had no more episodes of bleeding Some months later a follow-up letter was sent, and the following reply was noted He had vomited no blood since his discharge from the hospital However, he had black tarry stools on two occasions in 1946 and on one in January 1947 He also had hemorrhoids and attributed some red blood in the stools to this source He felt fairly well The red blood cell count was near 3,500,000 He was able to walk and drive a car He was admitted to another hospital, where two transfusions were given He had at this time considerable fluid in the abdominal cavity, which was drained off He stated that he felt that the procedure did not get all the leaky veins and that more work might have to be done eventually

#### COMMENT

The results recorded in the medical literature and the 2 cases herein reported lead to one conclusion, that the injection procedure is one of relative safety and represents a more reasonable course of action than doing nothing or making a much more radical approach to this type of varix by a transabdominal route The principle that the simplest and safest procedure that is effective should be the one of choice seems in this condition most demanding The transabdominal surgical alternatives are the ligation of the coronary vein or the ligation of this vein combined with a "retrograde" injection of the collateral vessels In this way the sclerosing is accomplished from below rather than from above

In all previous cases reported in this country as well as in those herein reported the procedure has proved to be innocuous The worst immediate complication has been pain There have been late failures but no late complications The "failures" may have been from missing small

varices at the time of the original injections. They represent a small percentage of the total number of patients treated. I have found no comparable record of effectiveness and safety with the other surgical solutions.

Possible complications include hemorrhage at the time of injection, necrosis and perforation of the esophagus, ulceration of the esophageal wall and hemorrhage from misplaced sclerosing solution. None of these are recorded as the experience in those cases previously reported or in these 2.

The chief indication for the procedure becomes clear from the substance of this and previous reports. It is the presence of esophageal varices with or without hemorrhage, obstruction or dysphagia. Contraindications depend on judgment, balancing the threat of the varices and the condition of the patient. As nonabsolutes, advanced cardiac disease, advanced age, terminal state and marked hypertension should be considered. Also to be listed are anatomic deformities of the spinal column, the mouth or the jaw that would render endoscopic examination impossible. The technic is that of cautious endoscopic examination. It is better to accomplish the result in several sittings, if the introduction of the scope presents no difficulties, than to try to accomplish all at once. No stronger than 2.5 per cent solution of sodium morrhuate should be used, and every patient should have a prior skin test for sensitivity to this drug. Adequate preoperative sedation is mandatory. The base of the varix should be engaged in the lip of the scope to fix it. Pressure should be continued to localize the area of reaction. The patient should be in an exaggerated Trendelenburg position. This should tend to cause the sclerosing material to flow toward the head and thus act on a larger segment of the vein.

The unfinished nature exhibited in 1 of my patients and the two late hemorrhages that followed in 2 of the patients of Rouse and Patterson emphasize the necessity for careful, long term follow-up. This should be done for six to twelve months at least. There remains the possibility of recanalizations because of the increased pressure distal to the thrombus in the portal system.

Further studies and observation are required by the internist and the endoscopist in the analysis of this problem. They would like to know what happens to the collateral veins when the esophageal veins are occluded. What should venography show? What happens to the pressure in the portal system, and what effect does this procedure have on hepatic function? Presumably the blocking off of a working shunt around the liver bed should raise pressure and increase or precipitate ascites. Is this presumption correct?

## SUMMARY AND CONCLUSIONS

Two cases in which esophageal varices were associated with Banti's disease are reported. In one case an apparent excellent and permanent result was demonstrated following injection of a sclerosing solution. In the second case improvement was shown, but the course indicated that examination and treatment may need to be repeated for a period of at least a year.

The procedure of injection is not difficult for a trained endoscopist. It is simpler and safer than the nonendoscopic methods used heretofore.

A small amount of bleeding should be no deterrent to continuing the procedure. Bleeding is not usually started by this procedure.

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## OTOSCLEROSIS ASSOCIATED WITH OSTEOPOROSIS AND LABYRINTHITIS CHRONICA OSSIFICANS

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THE MICROSCOPIC changes in otosclerosis are well known, although several questions, particularly those concerning the onset of the pathologic changes, remain unanswered. The etiology of otosclerosis, however, is a problem, neither examinations of human temporal bones nor experimental work has succeeded in solving it. For this reason the classification of otosclerosis as a pathologic entity is likewise problematic, and investigations which may eventually shed light on the etiology and the pathologic type of otosclerosis are of interest. An investigation of this sort is based on the question of whether systemic disorders, metabolic or endocrine in origin, or pathologic changes in the entire capsule of the labyrinth exert an influence on the progress of otosclerosis. Some work on the subject is available. For example, Mayer<sup>1</sup> examined a temporal bone presenting an association of otosclerosis and osteitis deformans. I examined a temporal bone in a case of otosclerosis associated with ochronosis.<sup>2</sup> From these and other reports, the conclusion can be drawn that no systemic disorders or diseases of the entire capsule of the labyrinth have been discovered which modify the pathologic changes in otosclerosis.

The following case of otosclerosis and osteoporosis of the capsule of the labyrinth is an additional contribution to the literature. The labyrinthitis chronica ossificans in the inner ear increases the importance of the case.

### REPORT OF A CASE

The patient was a 41 year old white man with dementia precox. He was deaf, but he understood lip reading. He died of empyema of the chest. Autopsy revealed empyema of the right pleural cavity, collapse induration of the middle lobe of the right lung and the lower lobe of both lungs, coronary sclerosis, myocardial fibrosis, edema of the left lung and splenitis.

*Macroscopic Examination of the Temporal Bones*—The mastoid process on both sides and the apex of the left petrous portion were diploic. The carotid and sigmoid

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1 Mayer, O. Untersuchungen über die Otosklerose, Vienna, A. Holder, 1917

2 Brunner, H. Ueber die Veränderungen des Schläfenbeines bei der Ochronose, Monatschr. f. Ohrenh. 63 997, 1929

sinuses were normal. At the posterior surface of each temporal bone there were two hyperostoses. One encircled the opening of the internal auditory meatus, the other was located close to the superior angle of the petrous bone and was approximately 1 cm in length.

*Microscopic Examination of Temporal Bones*—The observations were essentially the same on the two sides.

*Eustachian Tube, Middle Ear and Mastoid Antrum* The mucous membrane of the tube was slightly thickened, owing to an increase of connective tissue, and was covered with a cubical epithelium. The tensor tympani muscle and the drum membrane were normal. The tympanic cavity was large, it did not contain fluid.

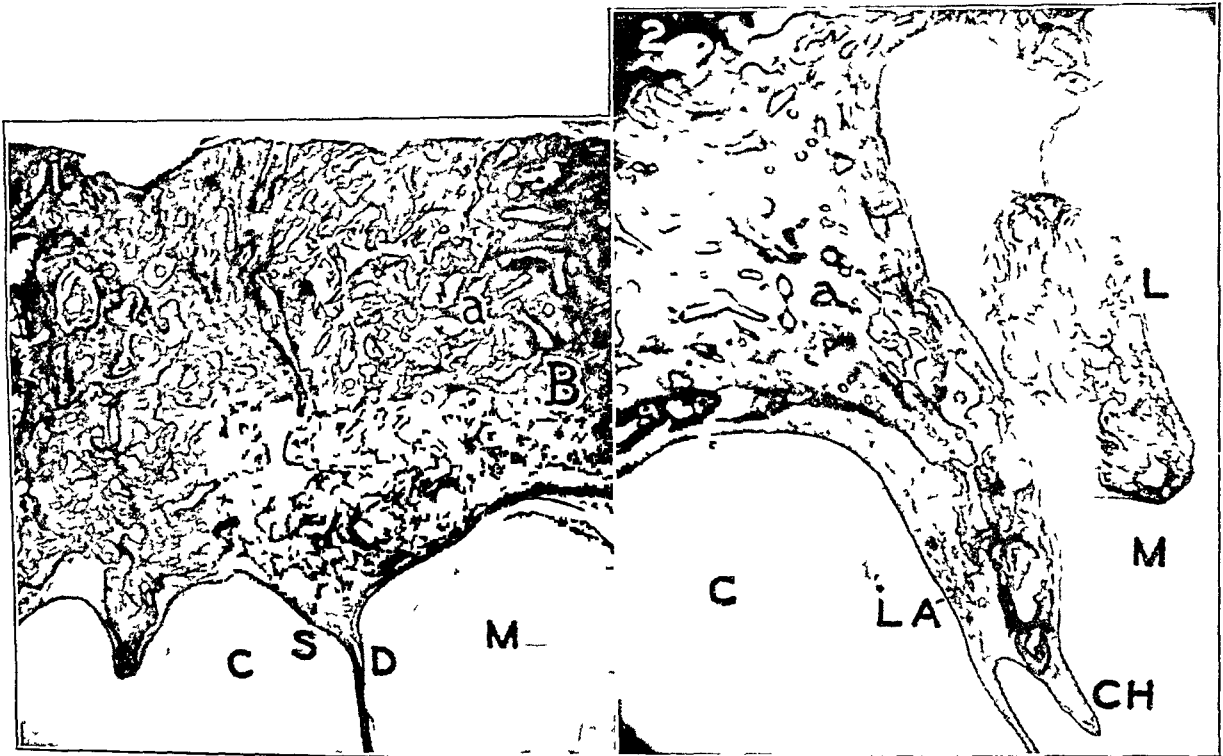


Fig 1—1, section through the inferior insertion of the drum (*D*), the external auditory canal (*C*), the tympanic cavity (*M*), (*S*) spongy bone (osteoporosis), (*B*) normal bone of the inferior wall of the tympanic cavity, (*a*) boundary between osteoporotic and normal bone. 2, section through the lateral wall of the attic (*LA*), the incus (*L*), the tympanic cavity (*M*), the chorda tympani (*CH*) and the external canal (*C*), *a-a* boundary between osteoporotic and normal bone.

The mucous membrane of the tympanic cavity was slightly thickened, and the epithelium was flat or cubical. The epitympanum (attic) was large and empty, the tegmen tympani was diploic. The annulus tympanicus, particularly in the area of the lateral wall of the attic, consisted of spongy bone (fig 1), the trabeculae of which were formed of weblike bone. The bone had a large number of small cavities which did not contain osteocytes, indicating atrophy of the bone trabeculae. Between the trabeculae were numerous marrow spaces filled with connective tissue and capillaries, but there was neither osteogenesis nor osteoclasia. The drum made its insertion at the cancellous atrophic bone (fig 1).



The malleus and incus presented advanced osteoporosis (fig 1). There were large marrow spaces, filled with loose connective tissue and hyperemic capillaries. The bone trabeculae were definitely atrophic and frequently presented Howship's lacunas, but there were no osteoclasts. Within the marrow spaces an inconspicuous metaplastic ossification of the connective tissue had taken place. The superior and posterior walls of the external canal and the short process of the incus were of different structure. There was cancellous bone, with small marrow spaces between the bone trabeculae. The latter consisted of weblike bone, rich in osteocytes. The marrow spaces were filled with connective tissue and capillaries. The boundaries of the marrow spaces were covered with a line of blue cement and were aplastic. The stapes was normal. The mastoid antrum was large and did not contain fluid or connective tissue.

**Membranous Internal Ear.** Although the internal ear was badly damaged in preparation for the examination, the following information was obtained. There was an accumulation of connective tissue in both scalae. Within the connective tissue, occasional small cysts and frequently a network of spicules of calcium or newly formed bone were observed (fig 2 1). On the right side there were adhesions in the scala tympani of the upper portion of the basilar coil and in the lower portion of the middle coil of the cochlea. The adhesions, which included pigment and calcium, pulled the lamina spiralis ossea, as well as the basilar membrane of the cochlea, toward the floor of the scala tympani, causing obliteration of the scala tympani and a compensating dilatation of the scala vestibuli. On the right side there was a septum vestibulocochleare,<sup>2a</sup> which had grown together with Reissner's membrane of the vestibular coil of the cochlea. The endochondral layer of the capsule of the labyrinth, which was in contact with the mass of connective tissue within the cochlea, had a smooth surface, that is, it did not present signs of bone absorption or bone deposition (fig 2 1). At several places, Reissner's membrane had grown together with the connective tissue within the scala vestibuli. This caused a pronounced dilatation of the cochlear canal, except in the lower part of the basilar coil, where the cochlear canal had a normal configuration. The cochlear canal did not contain pathologic fluid or connective tissue. In the larger part of the cochlea, the crista spiralis was greatly lowered, the spiral nerve, the spiral ganglion, the organ of Corti and the stria vascularis were absent, and the ligamentum spirale was much diminished in size. In the basilar coil on the left side, the stria vascularis was present but strongly atrophic.

The modiolus consisted of a small amount of bone trabeculae (fig 2 1). The channels of the modiolus were covered with a thick layer of calcium and contained much loose connective tissue. The number of ganglion cells and nerves was greatly diminished. The blood vessels had very thin walls, they were either obliterated or empty. The amount of pigment was normal on the left side but apparently slightly increased on the right side. The nerves of the internal meatus, except the facial nerve, contained a great amount of degenerated myelin sheaths and connective tissue. The vestibular ganglion appeared normal. The sacculus on the right side was dilated, the walls had grown together with the inner surface of the foot plate of the stapes, as well as with Reissner's membrane of the vestibular coil of the cochlea. The macula sacculi was atrophic on both sides. The cochlear aqueduct on the right side was obliterated by connective tissue. There was definite atrophy of the macula utriculi on the right side. The cristae were too much damaged to permit conclusions regarding them, however, the pigment of the cristae was appar-

2a Alexander, G. Labyrinthitis chronica ossificans. Ein Beitrag zur Anatomie der Taubstummheit, *Monatschr f Ohrenh* 40 489, 1906.

ently increased. On the left side there was a subepithelial area of hyalin at the slope of the crista of the external ampulla. Within that area there was an accumulation of pigment, which produced slight bulging of the wall of the ampulla toward the lumen. The ampullousacicular channel contained only a small amount of nerve fibers.

**Bony Capsule of Internal Ear.** In the area of the cochlea the periosteal layer was very well developed. It contained large marrow spaces, which were filled with fat or with lymphatic marrow. The boundaries of the marrow spaces were aplastic, and the bone trabeculae consisted largely of lamellar bone. The marrow spaces extended deep into the endochondral layer and may occasionally have reached the endosteum (fig 2 1). The marrow spaces within the endochondral layer contained fat or connective tissue exclusively, there was no lymphatic marrow. The

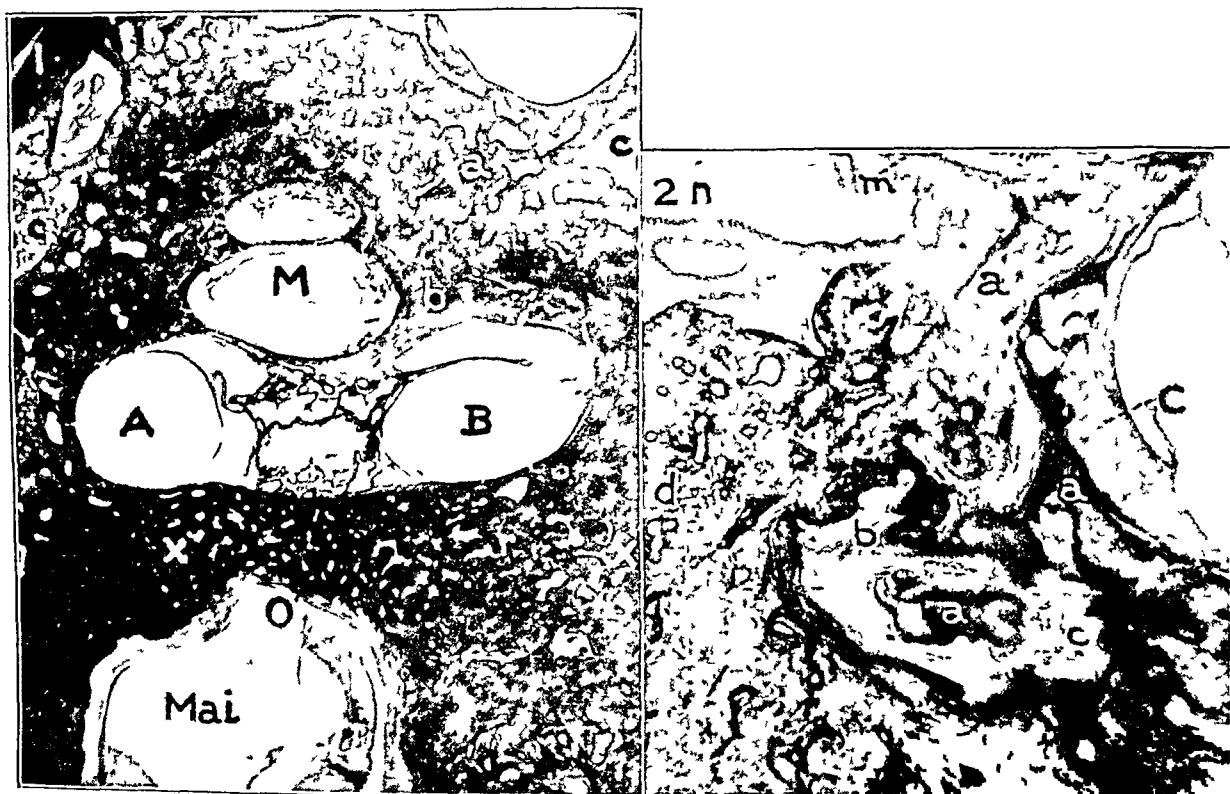


Fig 2—1, section through the internal auditory meatus (*Mai*) and the cochlea on the left side, (*x-x*) boundary between otosclerotic bone (*O*) and normal bone, (*A*) upper basilar coil of cochlea, damaged by preparation, (*B*) basilar coil, showing absence of organ of Corti, (*a*) osteoporosis, (*b*) remnants of endochondral and endosteal bone, (*c*) large marrow spaces in the periosteal layer. In the tangential section through the middle coil (*M*) and the tip of the cochlea there are newly formed connective tissue containing trabeculae of newly formed bone and narrowing of the lumen of the cochlea, particularly at the tip of the cochlea. Note the smooth walls of the osseous cochlea, the absence of the spiral ganglion and the blood vessels of the modiolus, surrounded by calcium and newly formed bone. 2, an otosclerotic area at the round window (*m*) and the inferior ampulla (*C*) on the right side, (*a*) remnants of the endochondral bone of the capsule of the labyrinth, (*b*) osteoid substance, (*c*) connective tissue, (*d*) weblike bone, (*n*) recess of round window

bone trabeculae in this area consisted of weblike bone, rich in osteocytes. The marrow spaces within the endochondral layer were more pronounced on the left side than on the right.

In the fundus of the internal auditory meatus there was a large area of otosclerosis (fig 2 1) This area consisted either of cancellous bone or of solid, weblike bone, which contained several obliterated blood vessel channels and which showed advanced basophilia In the latter there were numerous small marrow spaces, which contained connective tissue and capillaries Within the otosclerotic area there were remnants of the original capsule of the labyrinth, consisting of lamellar bone These remnants showed many Howship lacunas and were surrounded either by connective tissue of a marrow space or by the weblike bone of the otosclerotic area In the latter case there was a line of cement between the two types of bone Where the otosclerotic area was adjacent to the solid bone of the endochondral layer, its boundaries were sharp, where the area was adjacent to the osteoporotic bone of the periosteal layer of the capsule of the labyrinth, its boundaries were less distinct

In the areas of the saccule and the vestibular portion of the cochlea, the periosteal layer, adjacent to the posterior cranial fossa, had a thickness of 3 to 4 mm, where it was adjacent to the middle fossa, it was somewhat thinner It had the same structure as in the area of the cochlea, except that there was connective tissue in several marrow spaces close to the middle fossa The endochondral layer was normal and contained only a small number of interglobular spaces In front of the oval window there was an otosclerotic focus, consisting of trabeculae of weblike bone and of small marrow spaces, filled with connective tissue and hyperemic capillaries and having aplastic boundaries The otosclerotic focus had sharp boundaries toward the endochondral bone, while the boundaries toward the periosteal bone were less pronounced

Toward the utricle and the semicircular canals the otosclerotic area increased rapidly in size, particularly on the right side (fig 3) Ultimately, the otosclerotic area had encircled the entire utricle and the vestibular portion of the cochlea and had caused ankylosis of the stapes on each side The structure of this large area was not uniform, however, the newly formed bone was exclusively of the weblike type and had an enormous amount of osteocytes, it had no interglobular spaces At the mesial wall of the utricle and in the promontorium the new, weblike bone formed compact bone, with a great number of blood vessel channels These channels ran in different directions and occasionally caused a starlike formation They had a thick, hematoxylin-blue sheath and were largely obliterated, occasionally they contained a capillary Where the newly formed, solid bone came in contact with the endosteum of the internal ear, it was atrophic and showed Howship lacunas, but practically no osteoclasts (This is a typical finding in otosclerosis) In no place did the new bone invade the internal ear Not infrequently the newly formed, weblike bone included remnants of the original endochondral layer, consisting of lamellar bone (fig 3)

At other sites in the otosclerotic area, there were marrow spaces of different sizes In the frame of the oval window the marrow spaces were small, contained hyperemic blood vessels and connective tissue and were rich in cells (fig 3) In these spaces there was considerable osteogenesis, but no bone resorption At other sites the marrow spaces were large and may have extended to the macula cribrosa of the lateral or posterior semicircular canal, to the endosteum of the elliptic recess or to the periosteum of the cisterna perilymphatica The content of the large marrow spaces differed, however, they invariably contained loose connective tissue, and they often contained hyperemic capillaries Not infrequently small pieces of the original endochondral layer were embedded in the connective tissue (fig 2 2) These pieces usually showed Howship lacunas, but there were no osteoclasts, and

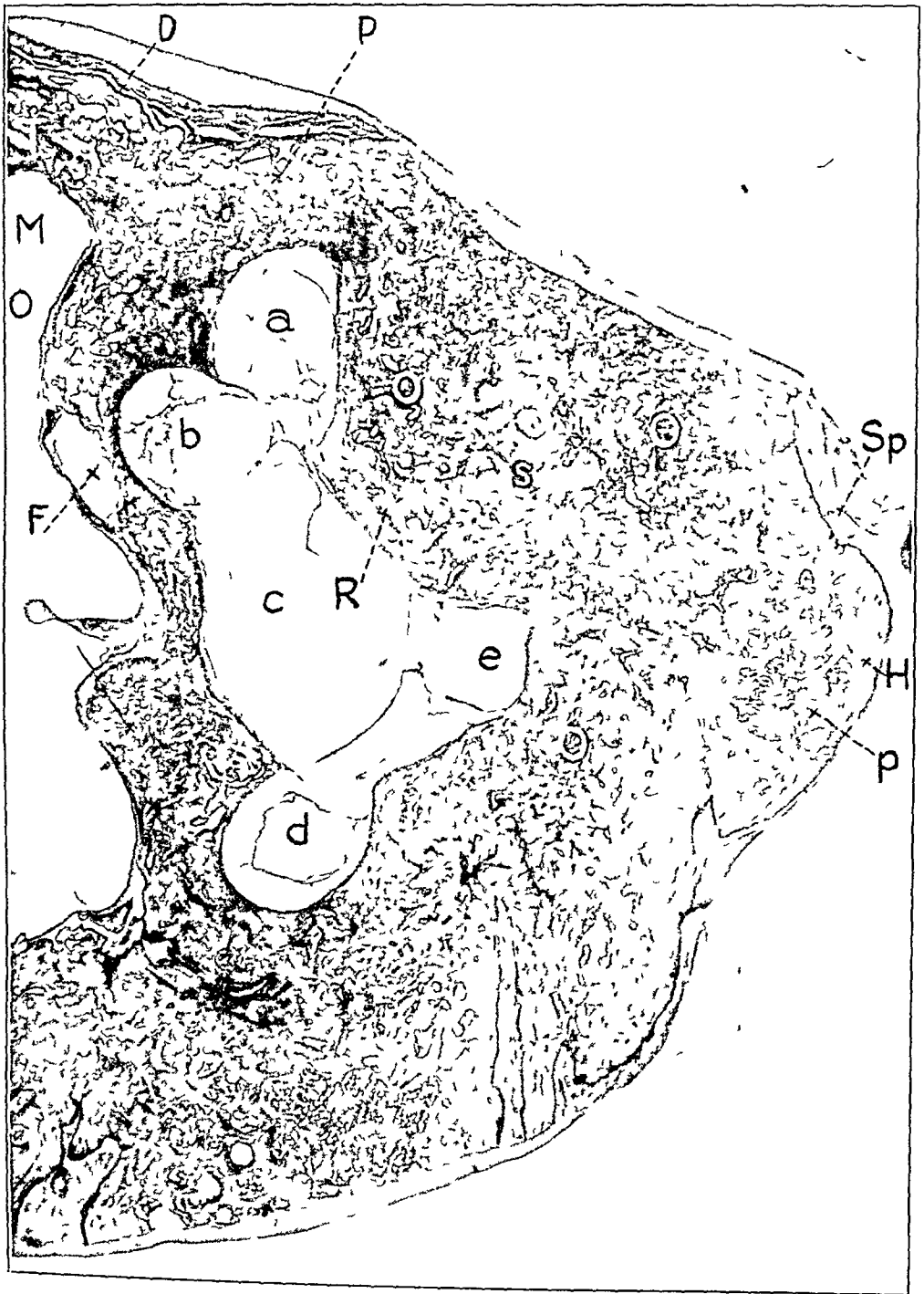


Fig 3—Section through the tympanic cavity (*M*), the superior ampulla (*a*), the lateral ampulla (*b*), the recessus ellipticus vestibuli (*c*), the inferior ampulla (*d*) and the crus commune (*e*), (*F*) facial nerve, (*T*) tegmen tympani, (*D*) dura, (*P*) periosteal layer of labyrinthine capsule, (*R*) remnant of original endochondral bone, (*O*) otosclerosis, (*s*) subarcuate fossa, (*Sp*) petrosal superior sinus, (*H*) hyperostosis

the surface of the pieces was usually covered by a line of hematoxylin-blue cement. In addition, there was a metaplastic ossification within the connective tissue, however, the amount of newly formed bone was small (fig 22). The boundaries of the large marrow spaces were aplastic and were covered by a hematoxylin-blue line. The otosclerotic area had sharp boundaries toward the remnants of the endochondral layer. Toward the periosteal layer the boundaries were not so sharp, but there was usually a line of separation.

Toward the ampullae of the semicircular canals, the otosclerotic area increased further in size and replaced, more and more, the periosteal layer above the superior semicircular canal. At this site the otosclerotic area extended to the dura of the middle cranial fossa, while there was a periosteal layer of extreme thickness and osteoporotic structure between the otosclerotic area and the dura of the posterior fossa. The osteoporotic periosteal layer adjacent to the dura of the posterior fossa bulged into the posterior fossa, forming the hyperostoses (fig 3) mentioned in the foregoing report on the macroscopic examination of the temporal bones. It is interesting that the otosclerotic bone did not extend to the blood vessels and connective tissue of the subarcuate fossa (fig 3). The latter was surrounded by the original bone of the capsule of the labyrinth. Toward the semicircular canals the otosclerotic area retained its extension, viz, otosclerotic bone embraced all semicircular canals, but again spared the area of the subarcuate fossa. It reached the dura of the middle fossa but not the dura of the posterior fossa. The structure of the bone in this area was essentially the same as in the area of the utricle.

#### COMMENT

The outstanding features of the present case were (1) otosclerosis, (2) osteoporosis, (3) hyperostoses at the posterior surface of the petrous bone and (4) labyrinthitis chronica ossificans.

*Otosclerosis*—The changes supposed to be caused by otosclerosis occupied a huge area of the petrous bone. This area was greatest in the osseous capsule of the utricle (fig 3) and in the semicircular canals. At this site the pathologic bone replaced almost the entire endochondral layer and a part of the periosteal layer, it extended to the dura of the middle fossa and toward the mucosa of the tympanic cavity. However, it spared the area of the subarcuate fossa and did not reach the dura of the posterior cranial fossa. Between the latter and the pathologic bone there was a periosteal layer, which, owing to the excess formation of pathologic bone within the petrous bone, bulged toward the posterior fossa, causing hyperostoses (fig 3). This indicates that the hyperostoses of the present case must not be confounded with the exostoses frequently found in otosclerosis. The latter are actual outgrowths of the capsule of the labyrinth, while the hyperostoses of the present case were caused by an increase in the diameter of the petrous bone, which, in turn, was caused by excess formation of pathologic bone in the core of the pyramid.

Toward the saccule and the cochlea, the area of pathologic bone became smaller, while the area of osteoporosis correspondingly increased in size. The pathologic bone withdrew from the dura of the

middle fossa and from the mucosa of the tympanic cavity, in the area of the cochlea it came to an end, at the fundus of the internal auditory meatus (fig 21)

In this vast area, the bone of the original labyrinth capsule had been absorbed and replaced by a newly formed bone, as evidenced by the following features

1 The bone had a weblike structure, in the normal endochondral layer of the mature labyrinth capsule there is no weblike bone

2 The weblike bone did not contain interglobular spaces, consisting of cartilage cells, the normal endochondral layer does

3 The weblike bone was formed in excess, causing hyperostoses For this reason, the nourishment of the newly formed bone was insufficient, inasmuch as the blood vessels of the bone were largely obliterated Consequently, the bone showed symptoms of decay, in particular close to the spaces of the internal ear This is a characteristic feature of otosclerotic bone<sup>3</sup> In contradistinction, the bone of the normal endochondral layer usually shows signs of senescence, indicated by the absence of osteocytes, but it does not show signs of decay

4 The pathologic bone included fragments of the original endochondral layer (fig 21 and fig 3) The margins of these fragments frequently showed Howship lacunas, caused by the activity of osteoclasts, although osteoclasts were practically absent

5 The pathologic bone included large marrow spaces, filled with connective tissue (fig 22), the normal endochondral layer in adults never contains large marrow spaces

6 Within the large marrow spaces, frequent fragments of the original endochondral bone were noted (fig 22)

7 Within the marrow spaces, osteogenesis had frequently taken place (fig 22), in the normal endochondral layer in adults, there is no osteogenesis

8 At the sites where the pathologic bone did not reach the maximum of extension, there was a sharp line between the pathologic and the normal bone

Based on these data, the following concept of the development of the pathologic changes is most likely A great part of the capsule of the labyrinth had been absorbed All three layers of the capsule of the labyrinth, particularly the endochondral layer, were involved The absorption did not involve the entire capsule Fragments of the endochondral layer and several interglobular spaces had been spared At the time of the death of the patient, the bone absorption, in general,

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3 Brunner, H Beiträge zur Histogenese des otosklerotischen Knochens, Ztschr f Hals-, Nasen- u Ohrenh 6 320, 1923

had come to an end. The absorbed bone had been replaced by web-like bone, which usually forms by metaplastic ossification of connective tissue. In the area of the vestibule and the semicircular canals there was an excess formation of weblike bone, nevertheless, the newly formed bone had not entered the spaces of the internal ear, although it caused hyperostoses of the petrous bone. Osteogenesis took place at the time of the death of the patient, osteoclasts had ceased. These observations, in the absence of an infection of the tympanic cavity or the internal ear, indicated the diagnosis of a diffuse otosclerosis, which is not so frequent as the localized form of otosclerosis and which must not be confused with osteoporosis.

*Otosclerosis and Osteoporosis*—The term "osteoporosis" indicates in general pathology an absorption of bone which slightly exceeds the limits of physiologic absorption, but after which there occurs no compensating deposition of newly formed bone. This causes the formation of large marrow spaces within the bone and renders the bone porous and brittle. In the temporal bones of senile persons this type of osteoporosis is not infrequent. In them it concerns the external portion of the periosteal layer of the capsule of the labyrinth, where, under physiologic conditions, bone absorption and bone deposition continue up to old age, though in slight degree. Rarely, osteoporosis of the temporal bones extends into the endochondral layer,<sup>4</sup> where neither bone absorption nor deposition normally takes place in adult life. In these instances, the solid bone of the endochondral layer is transformed into cancellous bone. The new marrow spaces within the endochondral layer may contain connective tissue or fat, may extend to the endosteum and may cause an increase in the size of the involved pyramid. Although this patient reached only the age of 41 years, osteoporosis was noted in the area of the annulus tympanicus and in the ossicles (fig. 1) and in the osseous capsule of the cochlea (fig. 2). In the latter the condition involved the periosteal layer as well as the endochondral layer.

In the present case there was a reciprocal relationship between otosclerosis and osteoporosis. Where otosclerosis extended over a large area of the petrous bone osteoporosis became less pronounced, and vice versa. However, since the temporal bones of the patient were involved by both diseases, the question arises whether the changes caused by otosclerosis show deviations from the typical pattern which eventually may be caused by osteoporosis. In order to answer this difficult question, one must bear in mind that the changes in osteo-

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4 (a) Wittmaack, K. Ueber einen Befund von wahrer Spongiosierung der Labyrinthkapsel, *Ztschr f Ohrenh* 77 201, 1918. (b) Mayer<sup>1</sup>. (c) Nager, F. R., and Meyer, M. *Die Erkrankungen des Knochensystems und ihre Erscheinungen an der Innenohrkapsel des Menschen*, Berlin, S. Karger, 1932.

porosis are primarily caused by a diminished activity of osteoblasts, while osteoclasts manifest a normal, or even slightly increased, activity. The diminished activity of the osteoblasts is supposed to be caused by diminished vitality of the person involved. The information on the otosclerotic area in this patient apparently indicates a precisely reversed activity of osteoblasts and osteoclasts, viz., an increased activity of osteoblasts and almost quiescent osteoclasts. In fact, there was a definite osteogenesis in the otosclerotic area even at the time of the patient's death. This apparently indicates that osteoporosis does not exert an influence on the progress of otosclerosis. Though Mayer<sup>1</sup> arrived at the same conclusion, it is not entirely correct. The diminished activity of the osteoblasts, which is the most characteristic feature of osteoporosis, concerns their ability to form lamellar bone, but not to form weblike bone. In the present case there was osteogenesis in the otosclerotic area, but the new bone was weblike, while lamellar bone was entirely absent. On the contrary, there was lamellar bone, though not in great amount, in the cases of diffuse otosclerosis studied by Nager and Meyer<sup>4c</sup>. These cases, however, were not associated with osteoporosis. Thus one arrives at the following conclusion: Osteoporosis apparently does not exert a strong influence on the progress of otosclerosis, but it may delay the formation of lamellar bone. The formation of weblike bone, caused by otosclerosis, is not counteracted by an osteoporosis of the capsule of the labyrinth.

*Labyrinthitis Chronica Ossificans*—Labyrinthitis chronica ossificans is characterized by the formation of connective tissue and bone within the internal ear, particularly in the perilymphatic spaces, in the absence of inflammatory changes in the capsule of the labyrinth. Labyrinthitis chronica ossificans is usually the final result of a serous inflammation of the internal ear, the serous exudate being transformed into connective tissue and bone. Purulent inflammations of the internal ear may cause a similar condition, however, in these instances labyrinthitis chronica ossificans is associated with purulent inflammation of the capsule of the labyrinth or with scars after purulent inflammation. Labyrinthitis chronica ossificans occurs in syphilis, typhoid and leukemia and after head injuries. In the present case, it was associated with diffuse otosclerosis and osteoporosis. Likewise, Nager and Meyer<sup>4c</sup> noted labyrinthitis chronica ossificans in a few cases of diffuse otosclerosis.

This finding raises the question whether labyrinthitis chronica ossificans is caused by otosclerosis and osteoporosis of the capsule of the labyrinth. Many years ago Siebenmann<sup>5</sup> advanced the hypothesis that

5 Siebenmann, F. Totaler knocherner Verschluss beider Labyrinthfenster und Labyrinthitis serosa infolge progressiver Spongiosierung, Verhandl. d. deutsch. otol. Gesellsch. 20: 267, 1911.



in otosclerosis metabolites liberated by the pathologic changes of the bone may pass the endosteum of the internal ear and cause a serous labyrinthitis. Several years later, I made use of this hypothesis in order to explain the serous exudate which I had noticed in several cases of osteitis deformans of the capsule of the labyrinth.<sup>6</sup> If this hypothesis were correct, it would be logical to establish a relationship not only between otosclerosis and serous labyrinthitis, but likewise between otosclerosis and the final result of serous labyrinthitis, viz., labyrinthitis chronica ossificans. Nevertheless, this concept is by no means incontestable. It was acceptable as long as the known causes of serous labyrinthitis were (1) inflammations of the tympanic cavity or of the meninges, (2) systemic infections, (3) leukemia or (4) injuries to the head. If these causative factors were absent from a case of otosclerosis or from one of osteitis deformans associated with serous labyrinthitis, one was compelled to assume that the serous labyrinthitis was caused by the pathologic changes of the capsule of the labyrinth. At present, the problem is more complex, since we know that serous labyrinthitis may be caused not only by the factors mentioned but also by vasomotor disorders independent of these factors. Consequently it is not permissible to establish, in the present case, a relationship between otosclerosis and labyrinthitis chronica ossificans. What the cause of the labyrinthitis ossificans was in the present case cannot be determined, as a dependable history was not available. However, the fact that there have been many cases of labyrinthitis chronica ossificans without otosclerosis and a great number of instances of diffuse otosclerosis without labyrinthitis ossificans indicates that the labyrinthitis chronica ossificans of the present case must be considered purely coincidental.

The labyrinthitis chronica ossificans explained this patient's deafness. The deafness in these instances is always profound, usually complete. It causes deaf-mutism if the labyrinthitis ossificans occurred in childhood.<sup>2a</sup> It must, therefore, be borne in mind that deafness in otosclerosis is not invariably caused by the disease, it may be caused by a disease of the internal ear, coincidental to otosclerosis.

#### CONCLUSIONS

1 Hyperostoses of the petrous bone in diffuse otosclerosis may be caused by an increase in the diameter of the petrous bone, which, in turn, is caused by excess formation of pathologic bone in the core of the pyramid.

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6 Brunner, H. Ueber einen Fall von Pagetscher Krankheit, Monatschr. f. Ohrenh. 56 810, 1922.

2 Osteoporosis apparently does not exert much influence on the progress of otosclerosis but it may delay the formation of lamellar bone. The formation of weblike bone, even in excess, caused by otosclerosis, is not counteracted by an osteoporosis of the capsule of the labyrinth.

3 Labyrinthitis chronica ossificans must be considered as purely coincidental to otosclerosis.

4 Deafness in otosclerosis is not necessarily caused by otosclerosis, it may be caused by a disease of the internal ear coincidental to otosclerosis, e g, labyrinthitis chronica ossificans.

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# UNUSUAL OTITIC FOREIGN BODIES

## Report of Two Cases

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AND

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A REVIEW of the literature in English since 1920 reveals reports of several unusual and interesting cases of a foreign body in the ear. Historically, each is an individual case, but all were the results of accidents. The purposes of this paper are (1) to record 2 additional cases which are similar both in nature and in subsequent diagnosis and treatment, and (2) to indicate a procedure for reducing the recurrence of otitic disturbances in such cases. Necessity for examination with instruments is emphasized.

### HISTORICAL REVIEW

Whale<sup>1</sup> reported an interesting otitic injury incurred by a soldier during World War I. A piece of shrapnel had been driven through both maxillary sinuses, the nasal cavity and the right orbit, with resulting destruction of the eye, and into the petrous bone. The soldier underwent several operations for plastic repair of the face and was considered cured. Approximately five years later he had a sudden onset of acute labyrinthitis, and roentgenograms revealed the metallic foreign body. A petromastoid operation effected removal of the shrapnel from the petrous bone, just above the superior semicircular canal.

Faulder<sup>2</sup> reported the case of a bead in the antrum tympanicum (mastoid antrum). He was unable to determine how the bead had gotten in the ear, or how long it had remained there. A simple mastoidectomy effected its removal, and the patient recovered without significant incident.

Three cases of lead bullets in the mastoid were reported by Hempstead<sup>3</sup>. The bullet in the first case caused intermittent otitis media

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1 Whale, H. L. An Unusual Case of Injury to the Petrous Bone, *Lancet* 2 1002 (Nov. 12) 1921

2 Faulder, T. J. Foreign Body in the Mastoid Antrum, *Proc. Roy. Soc. Med.* 14 26 (Nov.) 1920

3 Hempstead, B. E. Bullets in the Ear, *J. A. M. A.* 98 2281 (June 25) 1932

for a number of years, but it was not discovered and removed until sixteen years after its entry. In the second case, the bullet remained in the ear for eight years before its removal, by radical mastoidectomy. In Hempstead's last case, a bullet remained in the middle ear for five years before symptoms required its removal.

Bettington<sup>4</sup> reported the case of a 5 year old boy with a pussy willow catkin in his ear. Part of the foreign body had been removed at the time of the injury, and more had been removed later, with the use of general anesthesia. The ear did not heal, and six months later a simple mastoidectomy revealed the rest of the foreign body to be in the aditus.

Injuries of long duration in the ear were also reported by Mosher<sup>5</sup>. In 1 case a wound, made by a knife blade, through the external auditory canal into the middle cranial fossa caused meningitis in seventy-two hours. The knife blade was removed by mastoidectomy, and the tip of the blade was found just above the jugular bulb, in the middle cranial fossa. Mosher's second case was that of a 60 year old man who had been shot in the left mastoid. The ear gave him little trouble for thirteen years, after which signs of purulent otitis media developed. Fifteen lead fragments were removed from the mastoid region. During the operation an extradural abscess was discovered and drained. A radical mastoidectomy was eventually required to effect recovery.

In 1 of Wood's patients, a part of a scissors blade was found in the medial wall of the middle ear<sup>6</sup>. A raised window had fallen on a 4 year old child. The immediate result was complete facial paralysis, a few days later purulent otitis media developed. An otologist was consulted about nine months later, and roentgenograms revealed a metallic foreign body in the ear. At first it was thought to be leaded glass from the window, but radical operation revealed part of a scissors blade in the medial wall of the middle ear. The scissors, the family recalled, had been left in the window prior to the child's injury.

#### REPORT OF CASES

CASE 1—A Negro, 66 years of age, was referred to the otology service of Grady Memorial Hospital on Dec 14, 1946, with a diagnosis of purulent otitis media of the left ear. For about two weeks prior to his admission to the hospital the patient had been treated locally, with sulfadiazine administered orally and with injections of penicillin. An accurate history was not obtainable because of the patient's faulty memory, but he stated the belief that about four years

<sup>4</sup> Bettington, R. H. Peculiar Sequel to a Foreign Body in the Ear, *M. J. Australia* **1** 535 (March 19) 1938.

<sup>5</sup> Mosher, W. F. Foreign Bodies in the External Canal, Middle Ear and Mastoid and Their Complications, *Arch. Otolaryng.* **36** 679 (Nov.) 1942.

<sup>6</sup> Wood, V. V. Scissors Point Embedded in the Inner Tympanic Wall, with Facial Paralysis, *Ann. Otol., Rhin. & Laryng.* **39** 111 (March) 1930.

prior to the examination his left ear had discharged pus for two months. He had had no medical treatment at the time, the ear stopped draining spontaneously.

Ten months prior to his admission pus began draining profusely from his ear, during the next months he had what he described as "black-out spells" but he denied having experienced vertigo, fainting or unconsciousness. His health in general had been good. Poor vision, especially in the left eye, was his only complaint other than the discharge from his ear. He failed to comment on his poor hearing on the left side until asked about it. Then he said that he believed the ear was a little deaf but that he did not know how long such a condition had existed.

*Physical Examination*—The patient was well developed and adequately nourished and looked his age. He was rational and oriented and seemed to hear well. He had complete paralysis of the left side of the face, and the left eye did not move laterally when he looked to the left. His vision of 60/100 in each eye was considered good for distance. The eyegrounds showed nothing significant except arteriosclerotic retinopathy grade 1. His few remaining teeth were carious, with a 4 plus degree of pyorrhea. The right ear was normal,

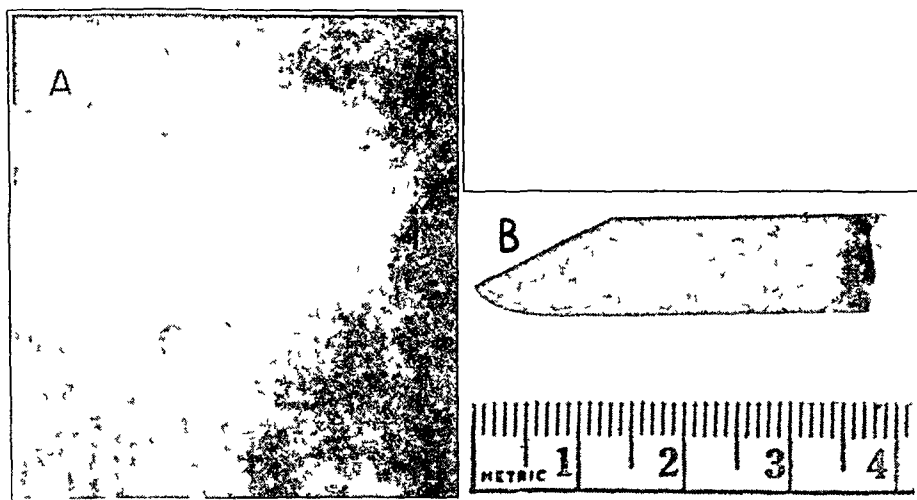


Fig 1—A, roentgenogram indicating foreign body in superior aspect of left petrous bone, B, knife blade after removal

hearing in that ear was approximately normal. The left ear had a profuse, foul, purulent discharge. Since the external canal was filled with a polyp-like growth, the drum membrane could not be seen. When the polyp was removed, neither the tympanic membrane nor the ossicles could be seen. No tenderness was elicited over the mastoid region. Hearing was then about 1/15 for a spoken voice, bone conduction was good. Complete neurologic examination revealed no abnormality except palsies in the sixth and seventh cerebral nerves. The blood pressure was 110 systolic and 70 diastolic. The patient's temperature was 98.0 F.

*Laboratory Examination*—The white blood cell count was 6,500, the urine was normal and the Kahn reaction of the blood was negative. Examination of the spinal fluid was not accomplished.

Roentgenograms of the mastoid and petrous portions indicated an opaque foreign body, measuring 3.7 cm in length, lying in the superior aspect of the left petrous bone (fig 1A). The foreign body extended from the bony wall

of the external auditory canal to a point approximately 5 mm inferior to the tip of the petrous bone. The entire petrous bone had the appearance of sclerosis consistent with petrositis. No cavities were noted in the petrous bone.

*Operation*—On Dec 31, 1946, surgical removal of the foreign body was accomplished by an endaural approach. The membranous wall of the external auditory canal was incised down to the annulus tympanicus, and the outer end of the foreign body was located in the anterior wall of the bony canal. It was easily removed with grasping forceps. The object was a rusty knife blade, 37 by 1 cc (fig 1*B*). When interrogated after the operation, the patient said that he had been stabbed in the ear about thirty years ago.

The exact cause of the facial and ocular palsies was not determined. The patient could not state the date on which they were first noticed, but he expressed the belief that the ocular paralysis was recent. When he was last seen, on

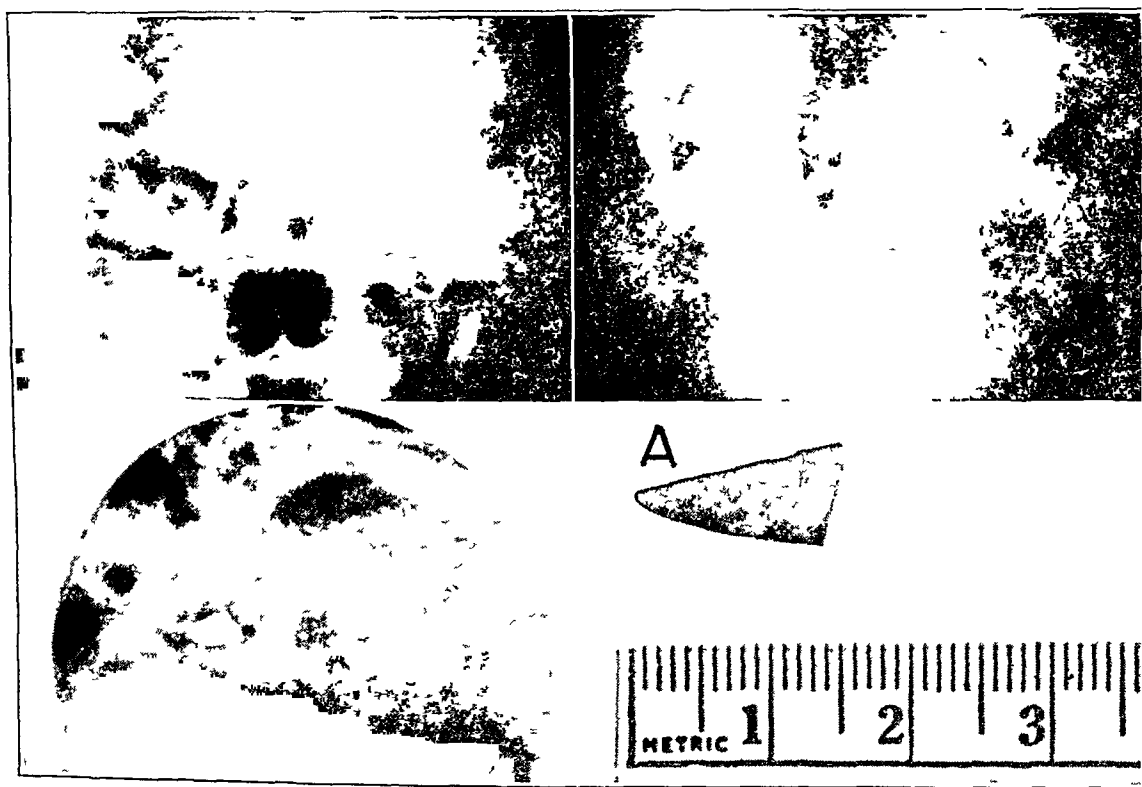


Fig 2—Roentgenograms indicating foreign body in region of left mastoid process. *A*, knife blade after removal.

March 7, 1947, the palsy of the sixth nerve had completely disappeared, but the facial palsy was unchanged. His ear had healed, no purulent discharge could be seen. His hearing was about 3/15 for whispered voice.

*CASE 2*—A 34 year old Negro woman was admitted to the Grady Memorial Hospital on Feb 12, 1947. She stated that she had been in a knife fight about November 1937 and had received a stab wound in front of the left ear. The laceration was treated at that time in the outpatient service, but the patient knew nothing of a knife blade's being in her ear, and the intern did not probe for possible foreign bodies. She had no otologic complaints until November 1945, when a large abscess over the left postauricular region developed and ruptured into the external auditory canal. She received outpatient treatment in

the clinic, the discharge stopped, and for the next fifteen months she had no otologic complaints except fleeting pains in the left ear. One week prior to admission, she began to have pain, tenderness and swelling over the postauricular area. The symptoms progressed to the point of extreme tenderness and pain in the mastoid region. Roentgenograms were taken for the first time (fig 2), and the following report was made:

"The films indicate a broken knife blade, measuring approximately 15 cm in length, in the region of the left mastoid process. The broken end of the blade is in the region of the posterior inferior wall of the external auditory canal. The tip of the blade has apparently entered the mastoid process anterior to the stylomastoid foramen. The mastoid cells appear to be sclerotic, but there is no evidence of mastoiditis or cholesteatoma."

The patient's hearing was never affected. The knife blade was removed in a simple mastoidectomy, by the postauricular route (fig 2). The mastoid cells were sclerotic. The patient had an uneventful recovery.

#### SUMMARY

Two unusual cases of foreign bodies in the ear are reported. In each case the origin was traumatic, and the foreign body was present for a number of years before a pathologic process in the ears was manifest to the patient or to the physician.

#### CONCLUSION

From the review of the literature and the present cases, it can be said that prolonged purulent otitis media may be caused by foreign bodies, of whose presence the patient is not necessarily aware. In all suspicious cases, therefore, roentgenoscopic examination should be made to determine whether a foreign body is present. Such a procedure would contribute both to the welfare of the patient and to the protection of the physician.

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## $p_H$ OF THE CUTANEOUS SURFACE OF THE EXTERNAL AUDITORY CANAL

A Study of Twenty-Seven Infants, Forty-Four Children and Sixty Adults

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AND

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ALTHOUGH it has been variously estimated that otitis externa constitutes from 5 to 40 per cent of all cases encountered in otologic practice in the United States<sup>1</sup>—the wide variation being due to sectional differences in temperature and humidity—renewed interest in infection of the external auditory canal is essentially a by-product of the war years. This situation is the result of the high incidence and widespread distribution of otitis externa among military personnel in humid tropical and subtropical regions. While the causative agent of otitis externa can be any one of a variety of bacteria and fungi, it is quite probable that the role of the latter, whether as primary or secondary agents of infection, has been exaggerated<sup>2</sup>.

The normal human skin harbors an enormous number of bacteria, which ordinarily are harmless. According to Price,<sup>3</sup> these may be divided into a resident and a transient population, the former usually remaining fairly stable. However, some influences, particularly heat and moisture, cause considerable changes in the number of bacteria found on normal skin. Sometimes pathogenic bacteria suddenly become members of the resident flora of the skin, they may then be extremely persistent and difficult to dislodge. Once a foothold is gained in skin already diseased, bacteria are responsible, in greater or less degree, for many diseases affecting the human skin. By virtue of its exposed position to the outside world, the external auditory canal is open to invasion by numerous micro-organisms, here a moist milieu containing cellular detritus and cerumen often serves as an adequate culture medium for the growth of bacteria and fungi.

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1 Gill, W D. Otitis Externa, *Ann Otol, Rhin & Laryng* **51** 370 (June) 1942

2 Syverton, J T, Hess, W R, and Krafchuk, J. Otitis Externa. *Clinical Observations and Microbiologic Flora*, *Arch Otolaryng* **43** 213 (March) 1946

3 Price, P B. The Bacteriology of the Normal Skin. A New Quantitative Test Applied to a Study of the Bacterial Flora and the Disinfectant Action of Mechanical Cleansing, *J Infect Dis* **63** 301 (Nov-Dec) 1938



In the opinion expressed by Pillsbury,<sup>4</sup> the problem of the management of bacterial infections of the skin cannot be dismissed simply by a discussion of the diseases produced, the bacteria concerned and the disadvantages of the various antibacterial agents now available, especially since these agents still have certain definite shortcomings. The management of the more difficult and more resistant cutaneous infections can be improved by a better understanding of the manner in which the skin resists and harbors bacteria and of some of the mechanisms by which bacteria produce harmful effects. Several factors apparently play a role in the remarkable protection afforded by the normal human skin against bacterial invasion. These factors, however, are imperfectly understood, and further basic study is necessary.

A factor of considerable importance is the  $p_H$  of the skin. Marchionini and Hausknecht<sup>5</sup> determined the  $p_H$  of the skin and found that the surface of the skin is enveloped (figuratively speaking) by an "acid cloak," which exhibits pronounced defense against bacterial invasion. The normal "acid mantle" of the skin's surface is dependent on cornified horny cells, whose reaction is more acid than that of any other cutaneous tissue, sweat, secretions of the sebaceous or oil glands, and the apocrine glands, which are probably the chief producers of the odoriferous cutaneous secretions.

In a series of studies, Blank<sup>6</sup> measured the  $p_H$  of the surface of the skin of a series of 100 male medical students and 100 women nurses, aged 19 to 27, and found the  $p_H$  to vary from 4.0 to 7.0. Most of the  $p_H$  readings were found to lie between 4.2 and 5.6, the average  $p_H$  of female subjects being 0.5 higher than that of male subjects. Examination of children, aged 3 to 14 years, revealed the variation in  $p_H$  to be the same as that in adults, namely, 4.0 to 7.0. Most of the  $p_H$  readings fell between 4.2 and 6.0, the average  $p_H$  of girls being from 0.2 to 0.3 higher than that of boys.

In investigating the  $p_H$  of the skin of seborrheic patients, Marchionini found that the seborrheic areas of the body are more alkaline than other parts of the skin's surface. The alkaline areas were shown to be less bactericidal than the rest of the skin, thus being predisposed

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4 Pillsbury, D. M. The Management of Bacterial Infections of the Skin, *J. A. M. A.* **132**: 692 (Nov. 23) 1946.

5 Marchionini, A., and Hausknecht, W. Sauremantel der Haut und Bakterienabwehr. I. Die regionale Verschiedenheit der Wasserstoffionenkonzentration der Hautoberfläche, *Klin. Wchnschr.* **17**: 663 (May 7) 1938, II. Ueber die regionale Verschiedenheit der Bakterienabwehr und Desinfektionskraft der Hautoberfläche, *ibid.* **17**: 736 (May 21) 1938.

6 Blank, I. H. Measurement of  $p_H$  of the Skin Surface. I. Technique, *J. Invest. Dermat.* **2**: 67 (April) 1939, III. Measurements on the Arms of Children with no Apparent Skin Lesions, *ibid.* **2**: 231 (Oct.) 1939.

to cutaneous infection Marchionini also demonstrated that there is a shift of the  $p_H$  of the skin toward the alkaline side in most cases of vesicular eczema. Some dermatoses are associated with excessive dryness of the skin, as the dryness becomes more pronounced, the tendency to fissure formation is increased, this tendency, in turn, contributes to an increase in alkalinity. Bernstein and Herrmann,<sup>7</sup> in studies of the  $p_H$  of the skin surface, found the highest degree of alkalinity in fissures present in eczematous processes.

Susceptibility to infection by bacteria is thought by many investigators to be due to the removal of the antibacterial "acid mantle" of the skin and its displacement by an abnormally "alkaline mantle." As in the case of bacterial micro-organisms, warmth and moisture are especially favorable to the propagation of many forms of fungi, the commonest fungi are known to multiply in the fertile soil supplied by damaged and swollen horny material. Indeed, moisture, maceration, dead horny tissue and relative alkalinity are four favorite conditions for the propagation of fungi causing such conditions as moniliasis, dermatophytosis ("athlete's foot") and ringworm of the groin.

In commenting on the acidity of the skin, Wise and Sulzberger<sup>8</sup> declared

These results confirm the fact of the normal acidity of the skin surface and the old-accepted concept of the protective function of the acid mantle. The logical conclusion, in managing many skin diseases is, therefore, not (as so popularly and manely reiterated) to "alkalinize" but rather to "acidify"—at least as regards the skin's surface. Experimental data show not that there is "too much acid" but rather that there may be too little acid on the skin surfaces in many instances of cutaneous infection and disease.

Generally, clinical experience has shown that alkalis are much more likely to produce lasting or severe cutaneous damage than are acids.

#### PRESENT INVESTIGATION

It will be recalled that the external auditory canal consists of a membranocartilaginous and a bony part, the entirety measuring about  $1\frac{1}{4}$  inches (3.2 cm) in length. The membranocartilaginous portion constitutes the outer one third of the canal, while the medial two thirds is bony. Development of the canal is complete by the third year of life. Hair follicles and sebaceous and ceruminous glands are present only in the membranocartilaginous portion, being absent in the bony part. It is the outer one third of the canal which is the seat of furuncles.

<sup>7</sup> Bernstein, E. T., and Herrmann, F. The Acidity on the Surface of the Skin, *New York State J. Med.* **42**: 436 (March 1) 1942.

<sup>8</sup> Wise, F., and Sulzberger, M. B. *Year Book of Dermatology and Syphilology*, Chicago, The Year Book Publishers, Inc., 1938, p. 553.

TABLE 1—Data on the  $p_H$  of the Cutaneous Surface of the Normal External Auditory Canal in 60 Adults

Patient	Age	Sex	Normal $p_H$ of Skin	Patient	Age	Sex	Normal $p_H$ of Skin
1	42	M	65 67 69	24	36	F	50 52 52
2	33	F	64 67 67	25	25	F	71 69 68
3	36	M	68 68 68	26	30	M	67 69 69
4	37	F	68 70 69	27	31	M	78 77 77
5	47	M	64 61 59	28	27	F	69 70 71
6	36	M	64 66 66	29	45	F	64 65 62
7	34	M	70 69 70	30	37	M	70 70 70
8	33	F	70 70 69	31	43	F	70 69 69
9	34	M	60 63 64	32	42	M	69 68 68
10	41	F	65 67 66	33	29	M	52 50 50
11	46	M	66 65 65	34	32	M	68 68 68
12	31	M	70 71 70	35	31	M	66 69 69
13	34	F	67 69 70	36	26	F	69 70 71
14	28	M	65 67 67	37	22	M	66 67 68
15	26	F	73 73 76	38	36	M	71 75 77
16	37	F	73 73 73	39	25	F	74 74 74
17	35	M	73 73 72	40	21	F	76 75 73
18	39	F	65 67 69	41	21	M	72 71 71
19	28	F	67 67 67	42	31	M	58 58 58
20	29	F	68 68 69	43	29	F	64 64 66
21	42	M	53 50 50	44	29	F	65 65 67
22	35	M	76 77 77	45	33	M	66 65 65
23	34	F	60 59 58	46	43	M	65 67 67

TABLE 1—Data on the  $p_H$  of the Cutaneous Surface of the Normal External Auditory Canal in 60 Adults—Continued

Patient	Age	Sex	Normal $p_H$ of Skin	Patient	Age	Sex	Normal $p_H$ of Skin
47	27	F	7.1 7.2 7.3	54	26	F	6.7 6.9 7.0
48	37	M	6.2 6.2 6.4	55	29	M	6.0 6.0 6.0
49	39	F	6.7 6.5 6.8	56	23	F	7.0 7.0 6.9
50	46	M	6.3 6.5 6.5	57	44	F	6.3 6.9 7.0
51	39	F	6.9 6.8 6.9	58	46	M	6.3 6.5 6.6
52	30	F	6.4 6.6 6.5	59	39	F	5.9 6.2 6.2
53	32	M	6.8 6.7 6.9	60	44	F	7.0 7.2 7.4

In the present investigation, measurement of the  $p_H$  of the cutaneous surface of the external auditory canal was undertaken in a series of 131 subjects (27 infants, 44 children and 60 adults) with no apparent lesions in their external auditory canals and either with no visible cerumen or with minimal amounts. A specially adapted silver-silver chloride glass electrode, employed in conjunction with the Coleman electrometer, was introduced into the external auditory canal so as to assure adequate contact with the cutaneous surface of the membrano-cartilaginous portion. Because of the inherent difficulty of carrying on  $p_H$  readings of the skin of the external auditory canal in infants and very young children over prolonged periods, for the sake of uniformity three consecutive readings were taken at one-half minute intervals in all three groups—infants, children and adults.

The 60 adults under study (30 men and 30 women) were parents of the infants and children. The ages of the men ranged from 21 to 47, the ages of the women, from 21 to 45. In the adult male group the  $p_H$  range of the skin of the external auditory canal was found to be from 5.0 to 7.8. In the adult female group the  $p_H$  range of the skin of the external auditory canal was found to be from 5.0 to 7.6. Of the 30 adult subjects, 23 evinced  $p_H$  values for the skin entirely within the acid range, 6, values within the alkaline range, and 1, a neutral  $p_H$ . Of the 30 adult female subjects, 21 evinced  $p_H$  values for the skin within the acid range, 6 within the alkaline range and 3 within a slightly acid, slightly alkaline range of fluctuations (table 1). From these observations, it appears that there is little difference in the  $p_H$  range of the skin of the normal external auditory canal of men and women of similar age groups. The  $p_H$  values fall chiefly within the acid range.

TABLE 2—Data on the  $p_H$  of the Cutaneous Surface of the Normal External Auditory Canal in 71 Infants and Children

Patient	Age	Sex	Normal $p_H$ of Skin	Patient	Age	Sex	Normal $p_H$ of Skin
1	2½	F	67 70 72	24	5	M	60 60 62
2	9 mo	M	75 75 76	25	8½	F	59 58 57
3	4½	M	71 73 74	26	2	F	62 63 63
4	11 mo	F	61 66 67	27	2	M	62 67 66
5	2	M	69 70 70	28	18 mo	F	60 63 64
6	3	M	71 71 72	29	2½	F	65 67 67
7	3 mo	M	57 62 62	30	5	F	67 69 69
8	4	F	71 75 77	31	7	F	62 69 69
9	9½	M	70 70 71	32	5	M	70 74 75
10	12	M	75 76 77	33	12	F	78 79 78
11	18 mo	M	65 66 70	34	9	F	69 70 69
12	2½	M	71 74 76	35	4	M	79 79 78
13	5½	M	77 74 77	36	1	M	75 74 76
14	3	M	64 64 64	37	4	M	63 67 67
15	8 mo	M	61 63 65	38	15 mo	F	74 74 74
16	11	M	75 75 74	39	3	M	65 61 65
17	13½ mo	F	57 58 57	40	4 mo	M	62 62 62
18	6	M	69 71 74	41	7½	M	67 69 70
19	13	F	68 69 70	42	10 mo	F	60 63 63
20	10 wk	F	62 61 63	43	23 mo	F	56 62 56
21	2½	F	64 65 68	44	6 mo	M	56 58 59
22	5	F	59 60 62	45	5 mo	M	66 69 68
23	3	M	65 66 67	46	5 wk	F	57 60 60

TABLE 2—Data on the  $p_H$  of the Cutaneous Surface of the Normal External Auditory Canal in 71 Infants and Children—Continued

Patient	Age	Sex	Normal $p_H$ of Skin	Patient	Age	Sex	Normal $p_H$ of Skin
47	4	M	70 72 72	60	7	M	60 61 60
48	10	M	75 75 76	61	9	F	70 72 75
49	8 mo	F	69 67 68	62	7	F	70 71 71
50	5	F	65 65 66	63	5	F	69 68 69
51	10½ mo	F	66 65 67	64	17 mo	M	67 68 69
52	4	M	64 65 66	65	14 mo	M	60 62 61
53	6	M	72 73 75	66	14 mo	F	62 63 63
54	8	F	65 68 69	67	4	M	74 73 73
55	2½	M	73 71 73	68	10	M	77 77 77
56	11	M	66 66 68	69	4 mo	F	52 55 55
57	3	M	63 66 68	70	6	F	70 71 70
58	8 mo	M	75 76 75	71	6½	F	68 69 69
59	17 mo	M	61 60 62				

The younger subjects under investigation numbered 27 infants (14 males and 13 females) and 44 children (23 males and 21 females). The ages of the male infants ranged from 3 months to 2 years and those of female infants from 5 weeks to 2 years. The ages of the male children were from 2 to 11 years and those of the female children from 2 to 13 years. In the group of male infants, the  $p_H$  range of the skin of the external auditory canal was from 56 to 76. In the group of female infants, the  $p_H$  range of the skin of the external auditory canal was found to be from 52 to 74. Male children, on the other hand, had a  $p_H$  range of the skin from 60 to 79, whereas female children had a range from 57 to 79 (table 2).

Of the 14 male infants, 11 evinced  $p_H$  values for the skin within the acid range, while values for 3 subjects fell within the alkaline range. Of the 13 female infants, 12 evinced  $p_H$  values of the skin entirely within the acid range and but 1 within the alkaline range. Of the 23 male children, 10 evinced  $p_H$  values for the skin within the acid range,

12 within the alkaline range and 1 within a slightly acid, slightly alkaline range of fluctuations. Of the 21 female children, 12 evinced  $p_H$  values for the skin within the acid range, 8 within the alkaline range and 1 within a slightly acid, slightly alkaline range of fluctuations.

From these observations it appears that there is little difference in the  $p_H$  range of the skin of the normal external auditory canal of male infants and that of female infants. The  $p_H$  values fall mostly within the acid range. Among children, the tendency for acid  $p_H$  values is not nearly so pronounced as that for other groups.

#### SUMMARY AND CONCLUSIONS

Renewed interest in infection of the external auditory canal is essentially a by-product of the war years. By virtue of its exposed position to the outside world, the external auditory canal is open to invasion by numerous micro-organisms, a moist milieu containing cellular detritus and cerumen often serves as an adequate culture medium for the growth of bacteria and fungi.

The management of the more difficult and more resistant cutaneous infections can be improved by a better understanding of the manner in which the skin resists and harbors bacteria and of some of the mechanisms by which bacteria produce harmful effects. Several factors play a role in the remarkable protection afforded by the normal human skin against bacterial invasion. These factors, however, are imperfectly understood, and further basic study is necessary.

A factor of considerable importance is the  $p_H$  of the skin. The surface of the skin is enveloped by an "acid mantle," which exhibits pronounced defense against bacterial invasion. Determinations of the  $p_H$  of the skin by other investigators reveal the following facts: (1) The seborrheic areas of the body are more alkaline than other parts of the skin's surface, (2) the alkaline areas are less bactericidal than the rest of the skin, thus being predisposed to cutaneous infection, (3) in most cases of vesicular eczema there is a shift of the  $p_H$  of the skin toward the alkaline side, (4) the highest degree of alkalinity is present in fissures associated with eczematous processes, and (5) moisture maceration, dead horny tissue and relative alkalinity are four favorite conditions for the propagation of many forms of fungi. It has been asserted.<sup>8</sup>

The logical conclusion in managing many skin diseases, is not to "alkalinize" but rather to "acidify"—at least as regards the skin's surface.

In the present investigation, measurement of the  $p_H$  of the cutaneous surface of the external auditory canal was undertaken in a series of 131 subjects (27 infants, 44 children and 60 adults) with no apparent lesions in their external auditory canals and either with no visible

cerumen or with minimal amounts. A specially adapted glass electrode was employed in conjunction with the Coleman electrometer.

In the group of adult male subjects, the  $p_H$  range of the skin of the external auditory canal was found to be from 5.0 to 7.8. In the group of adult female subjects, the  $p_H$  range of the skin of the external auditory canal was found to be from 5.0 to 7.6. Of 30 adult male subjects, 23 evinced  $p_H$  values for the skin within the acid range, 6, values within the alkaline range, and 1, a neutral  $p_H$ . Of 30 women, 21 evinced  $p_H$  values for the skin within the acid range, 6 within the alkaline range and 3 within the slightly acid, slightly alkaline range of fluctuations. From these observations it appears that there is little difference in the  $p_H$  range of the skin of the normal external auditory canal of adult male and adult female subjects of similar age groups. The  $p_H$  values fall chiefly within the acid range.

In the group of male infants, the  $p_H$  range of the skin of the external auditory canal was found to be from 5.6 to 7.6. In the group of female infants the  $p_H$  range of the skin of the external auditory canal was found to be from 5.2 to 7.4. Male children, on the other hand, had a range in the  $p_H$  of the skin from 6.0 to 7.9, whereas female children had a range in the  $p_H$  of the skin of from 5.7 to 7.9. Of 14 male infants, 11 evinced  $p_H$  values for the skin within the acid range, while those for 3 subjects fell within the alkaline range. Of 13 female infants, 12 evinced  $p_H$  values for the skin within the acid range and but 1 within the alkaline range. Of 23 male children, 10 evinced  $p_H$  values for the skin within the acid range, 12 within the alkaline range and 1 within a slightly acid, slightly alkaline range of fluctuations. Of 21 female children, 12 evinced  $p_H$  values for the skin within the acid range, 8 within the alkaline range and 1 within a slightly acid, slightly alkaline range of fluctuations. From these observations it appears that there is little difference in the  $p_H$  range of the skin of the normal external auditory canal of male and of female infants. The  $p_H$  values fall chiefly within the acid range. Among children the tendency for acid  $p_H$  values is not nearly as distinct as it is for other groups.

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## PROGRESS IN SURGERY OF THE SEPTUM

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**I**N A previous presentation, it was demonstrated how with the new procedure<sup>1</sup> one could, with safety, entirely excise a deformed septal cartilage and still support the nose by the use of the upper lateral cartilages and a columellar cartilaginous strut. Since then various modifications of the procedure have been advanced by other investigators (Fomon and others<sup>2</sup>). One modification by Galloway<sup>3</sup> in my opinion destroys what I consider the shock absorber action of the membranous septum because it traverses the membranous septum with a rigid cartilage graft. A columellar strut implanted into the columella by the Fomon technic is a more sound procedure physiologically. My experience has taught me that it is futile to attempt to correct scar contractures of the mucoperichondrial flaps by the employment of septal cartilage grafts. Regardless of the type of septal deformity, its correction must be achieved along the lines of proved surgical and plastic principles applied by an otolaryngologist trained in rhinoplasty who can improvise as the occasion arises.

I have waited before publishing many of the findings reported in 1944 because I felt that it was necessary to take sufficient time to evaluate the merits of the contributions made. Since the original presentation in 1944 by Kayser of the studies to be mentioned in this paper, there have been no modifications of any of the observations then noted, and they are now presented as then reported. Any operator

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Part of paper read before the American Otorhinologic Society for the Advancement for Plastic and Reconstructive Surgery, Inc., under the title "Rhinoplasty and Nasal Rhysiology" on November 11, 1944. Also read before the Section on Laryngology, Rhinology and Otology of the Medical Society of the County of Kings and Academy of Medicine of Brooklyn, on April 11, 1945, as part of paper titled "Rhinoplasty and the Submucous Resection as Aids Towards Improving Nasal Physiology with Presentation of a New Technic for Correcting the Dislocated and Obstructing Septal Cartilage Associated With and Without External Nasal Deformity."

1 Kayser, R. New Operation for Dislocated Septal Cartilage, *Am J Surg* 72 242-251 (Aug) 1946

2 Fomon, S., Syracuse, V. R., Bolotow, N., and Pullen, M. Plastic Repair of the Deflected Nasal Septum, *Arch Otolaryng* 44 141-156 (Aug) 1946

3 Galloway, cited by Formon, Syracuse, Bolotow and Pullen<sup>2</sup>

who is familiar with the post-traumatic distortions of the septal cartilage and bone and the scarring and contractures of the surrounding soft parts knows that although the correction of each septal deformity poses an individual problem the basic principle of working close to the bone and cartilage is a *sine qua non* for a satisfactory submucous resection. Similarly, I am now convinced that the Kayser procedure has simplified surgery of the septum because of its pioneer work in establishing the principle that one can, in selected cases, remove the entire septal cartilage without the danger of a saddle deformity.

Proetz<sup>4</sup> said that "aside from the removal of tumors and the correction of cosmetic shortcomings, surgery of the nose has only two functions—to eradicate infection and to restore physiologic harmony." This paper is concerned with the restoration of physiologic harmony, to be achieved by a submucous resection which may necessitate for its complete execution rhinoplastic procedures on the nasal framework. I wish to establish the concept that such rhinoplastic procedures as the removal of a nasal hump, the out-fracturing incidental to a lateral osteotomy or the transfixion of the nasal tip can facilitate the thorough execution of a complicated submucous resection. However, the fact cannot be stressed too strongly that no rule of thumb can replace the judgment of an experienced otolaryngologist in deciding when these steps are to be employed.

It is now the teaching on the service of Dr. Anthony Nigro at the Manhattan Eye, Ear and Throat Hospital that a knowledge of various systems and subdivisions of procedures is of little value if one is not familiar with the following facts. First one must know the physiologic function of the nose. More important still is a thorough knowledge not only of all the normal variations to be found in the anatomy of the bones, cartilages and soft structures of the nose but also of the distortions of these parts caused by trauma.

The principle functions which the rhinologist must conserve are

1. Sense of smell. Inasmuch as this is limited to the area of the distribution of the olfactory nerve, it is important that this area be kept clear.

2. Comfortable breathing of air currents. According to Proetz,<sup>4</sup> "both inspiratory and expiratory air currents pass in a high curve through the nasal chambers but only the expiratory currents enter the meatuses." It is evident that the direction of the nares as well as their size and shape can influence these airways. Nasal deformities which obstruct the high curve mentioned obstruct the airways. Any deformity which obstructs these airways must be corrected.

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<sup>4</sup> Proetz, A. W. *Essays on the Applied Physiology of the Nose*, St. Louis, Annals Publishing Company, 1941, p. 349.

3 **Moistening of the air** The nose secretes 1 liter of water every twenty-four hours. A protective blanket of mucus must be maintained on the nasal mucosa. The villi must be protected from drying. As a deviated septum can cause areas of drying, with subsequent catarrh and even headaches, the correction of such a septum by a submucous resection is physiologically sound.

4 **Heating of the air** Two and a half per cent of the loss of body heat occurs in the nose, where the air is heated to the body temperature. In order to achieve this the turbinates act as wall radiators. Because the outer framework of the nose is rigid, the turbinates by their capacity to swell quickly act as valves to the volume of air passing over them. Deformities of the nose and the septum accompanied with septal spurs and ridges which dig into the turbinates limit the capacity of the turbinates to respond physiologically to normal stimuli. Here too, therefore, the indicated operation is physiologically sound.

The following terminology will help clarify the description of the structures of the nose and their relationships to each other. Anterior and ventral are used interchangeably—away from the back. Posterior and dorsal are used interchangeably—toward the back. Cephalad means in the direction of the cranium, caudad, in the direction of the feet, ental, toward the center, ectal, in the direction of the surface, medial, toward the midline, and lateral, away from the midline. Thus the so-called dorsum of the nose is really the ventral or anterior aspect of the nose. The tip of the nose is at the anterior caudad end.

#### STRUCTURE OF THE NASAL FRAMEWORK

This discussion is concerned with the anatomy of the structures of the nasal framework and of the septum. The nasal framework is composed of a bony part and of a cartilaginous part. The bony part is made up of the two nasal bones. The nasal bones rest against each other medially to form the arch or bridge of the nose. Laterally, this arch or bridge of the nose is supported by the frontal processes of the maxillary bone. At the root of the nose the nasal bones are mortised into the nasal processes of the frontal bone. At this articulation the nasal bones are solid and heavy. Viewed from without, each nasal bone is first concave and then convex. At the junction of these two bends the nasal bone is thin, and this is the site where fracture most frequently occurs.

The cartilaginous framework is composed of the upper and lower lateral cartilages.

*Upper Lateral Cartilages*—The upper lateral cartilages are not separate cartilages at all. Actually they are winglike lateral prolongations from the anterior edge of the septal cartilage. The medial edge of the upper lateral cartilage is continuous with the entire anterior edge

of the cartilaginous septum. This medial edge may extend caudad to the caudal anterior end of the septum, or it may occasionally end short of the caudal end of the septum. As long as the upper lateral cartilages are united at their medial margins, they support the nose throughout their entire length. Naturally, only if they end short of the septum or if they are separated from each other does the septum offer support to the areas in question. It is in such cases that one must be on one's guard against a saddle nose when a submucous resection is done. Each wing of the upper lateral cartilage is usually roughly triangular in shape. The base of the triangle is thus the anterior edge of the

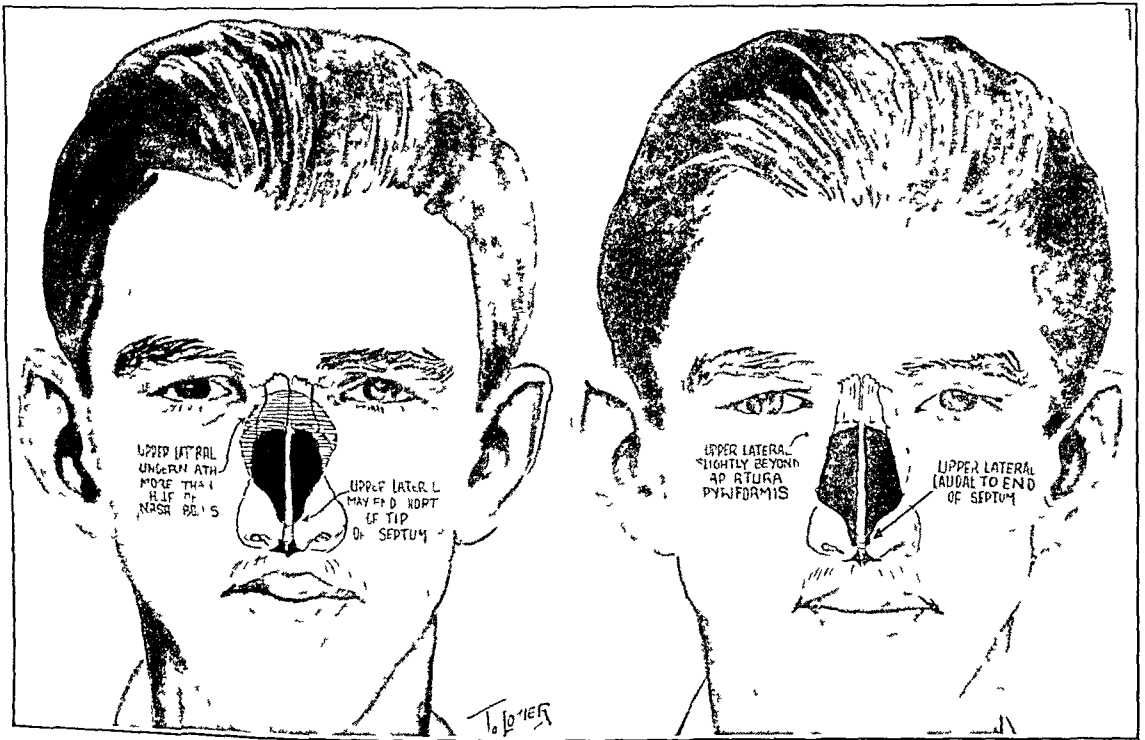


Fig. 1—Relationships of upper lateral cartilages may vary

septum. The cephalic part of the upper lateral cartilage is attached firmly by fibrous tissue to the medial aspect of the processus pyriformis. Occasionally the upper lateral cartilage may be quadrilateral. It is thickest at the septum and thins out laterally. The ectal surface is usually flat, occasionally it may be either concave or convex.

The cephalic edge of the upper lateral cartilage is always underneath the nasal bone medially and underneath the frontal process of the superior maxilla laterally and may extend in this relationship for a distance varying from 1 mm to almost the entire length of the nasal bone. Because of this anatomic relationship, when the soft structures of the nose are elevated from the nasal framework one must seek the

caudal edge of the nasal bone and then proceed anterior to it. Otherwise, if one followed the anterior surface of the upper lateral cartilage one would slip underneath the nasal bone and then penetrate into the nasal cavity.

Invariably the caudal edge of the upper lateral cartilage first runs for a distance of about 5 to 10 mm, paralleling and almost hugging the septum in a direction slightly dorsal to the ventral edge of the septum. I believe that this is an important relationship to retain, inasmuch as it forms a nasal cord, just as in the larynx there is a vocal cord. The remainder of the caudal edge of the upper lateral cartilage then swings laterally and cephalad toward the apertura pyriformis.

The upper lateral cartilage is usually attached to the septum at an acute angle. It has a natural springiness or elasticity. When the pars compressor of the nasalis muscle contracts, the upper lateral cartilage is pressed against the septum. When the muscle relaxes, the upper lateral cartilage, of its own inherent elasticity, recoils away from the septum and the aforementioned angle is reestablished. The maintenance of this angle is important in quiet nasal breathing. Rhinoplasty, to be physiologically sound, must conserve this angle, and it must create this angle if it does not exist. This is accomplished by placing a loose petrolatum pack at the site of the angle when the rhinoplasty is completed.

In the nasal vestibule the anterior caudal part of the upper lateral cartilage crosses the dome of the vestibule like a shelf. This shelf helps slice the air stream into more surfaces to be physiologically acted on.

The upper lateral cartilage is surrounded by a sheath of perichondrium. Anteriorly, part of this sheath is reflected onto the posterior surface of the lower lateral cartilage, becoming continuous with the perichondrium of the latter. This sheath is an aponeurosis-like structure through which the initial incisions are made in rhinoplasty.

*Lower Lateral Cartilages*—The lower lateral cartilages can best be visualized by imagining a teaspoon bent in the shape of a horseshoe with the handle somewhat pulled forward. The spoon-shaped part is the lateral crus. It gives the tip its shape and support. The handle is the medial crus. In the nose the two crura are connected by a dome-shaped expansion of the lower lateral cartilage. The variations in shape of the lower lateral cartilages are legion. The cephalad margin of the lateral crus rests on the upper lateral cartilage. The two medial crura and their surrounding structures form the columella of the nose.

*Mobile Nasal Septum*—The columella is freely movable on the cartilaginous septum. This motility is made possible by the membranous septum.

The membranous septum consists of a tough elastic membrane connecting the free end of the septum and the columella. It is triangular in shape, with the base at the under surface of the lower lateral cartilage. The brevity of this description of the membrane should not belie its importance. It is one of the most important structures in rhinoplasty, since on its treatment depends the success or failure of many rhinoplasties.

*Fixed Nasal Septum*—The rhinologist is familiar with the relationship of the cartilaginous septum to the perpendicular plate of the ethmoid.

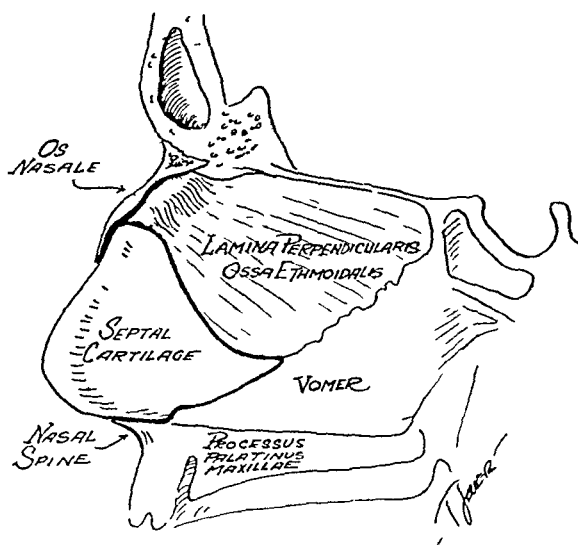


Fig 2—The septum. Note cartilaginous septum under nasal bones, irregularity of thickness of nasal bones and nasal spines and cartilaginous septum ventral to them.

and to the vomer. It is noteworthy that although the ventral aspect of the septum may be thin in the vicinity of the cribriform plate the septum may be post-traumatically as much as one-half inch (1.27 cm) in thickness underneath the nasal bones. Attention should be called to the folding screen arrangement by which the caudal edge of the cartilaginous septum rests in the groove of the vomer. The ridge and angulations frequently seen at this site are thus easily visualized as the natural result of a crushing injury. Proceeding ventrally, after the caudal edge of the septal cartilage leaves the vomerine and maxillary grooves, it lies unsupported between the nasal spines for a distance of about 4 mm. The so-called free margin of the septum then proceeds in a graceful curve cephalad and ventrally toward its union with the upper lateral cartilages.



for it is his work which for the first time described the facial muscles as actually seen in action

*Procerus Muscle*—These muscle fibers arise from the bone at the nasofrontal articulation. They proceed cephalad and are inserted into the skin between the eyebrows. Their contraction causes wrinkles of the forehead between the eyebrows.

*Nasalis Muscle*—The nasalis muscle is composed of two parts, the pars compressor and the pars alaris.

*Pars Compressor* The pars compressor is a thin flat muscle. It has its origin from the maxillary bone lateral to the apertura pyramiformis. It inserts into an aponeurosis on the ventral aspect of the nose. This aponeurosis is a common insertion for both pars compressors and thus helps make of the compressor muscles a nasal sphincter. There is a bursa underneath this aponeurosis. As the pars compressor runs ventromedially it crosses the cephalic part of the ala and then it crosses the upper lateral cartilage. Its contraction thus presses (1) the cephalic part of the ala inward and (2) the upper lateral cartilage toward the septum. A strong contraction of the pars compressor is necessary when saying "P" or "B". It is also strongly contracted in the crying infant. It is not so strongly contracted when "M" is voiced. This strong contraction of the pars compressor presses the part of the upper lateral cartilage just mentioned as the nasal stop against the septum. It helps create enough air pressure in the nose and mouth to burst the lips apart when such sounds as "P" "B" or "M" are voiced.

*Pars Alaris* The pars alaris is a fan-shaped muscle. It arises from the maxillary bone at the dorsal and canine margin of the apertura pyramiformis. Its lateral fibers insert into the caudal part of the ala. When these lateral fibers contract they pull the ala downward and outward. The pars alaris also sends fibers to the mobile part of the septum, being attached to the medial crura of the lower lateral cartilage, particularly to the winglike lateral flarings of the ends of the medial crura. Contraction of these fibers pulls the mobile septum downward. Here must be mentioned an upward extension of the muscle orbicularis oris called the depressor septi, which when it contracts also helps pull the mobile septum downward. Occasionally this depressor septi muscle is so prominent that it creates a webbing at the nasolabial angle. Its antagonist is the procerus muscle.

*Other Muscle Groups*—To understand the movements of the alae three more muscle groups must be studied.

1 *Pars angularis* of the quadratus labii superioris muscle. This angularis muscle arises from the frontal bone and the frontal process of the maxillary bone. Its most medial fibers proceed downward and



are inserted into the cephalic part of the ala. When these medial fibers contract they pull the ala upward. They are the antagonists of the lateral fibers of the pars alaris of the nasalis muscle. The middle fibers of the angularis muscle proceed downward and outward and then curve around the ala and are inserted into the upper lip near the philtrum. When these medial fibers contract they help to bring the ala medially and thus narrow the nostril. The lateral fibers of the angularis muscle are inserted into the angle of the mouth. It can thus be understood that the dominant action of the angularis muscle, in smiling or laughing, is to pull the ala upward and sometimes to cause a crease of the upper lip. 2 and 3 Anterior and posterior dilator nares muscles. These are two muscles reaching to the rim of the nostril, influencing its size and shape. The anterior dilator nares arises from the ectal surface of the lateral aspect of the lower lateral and upper lateral cartilages and inserts into the rim of the nostril. The posterior dilator nares muscle arises from the nasal notch of the superior maxilla and from the lateral sesamoid cartilages and inserts into the skin and the outer edge of the rim of the nostril. By their action they tend to dilate and evert the nostrils.

The innervation of this entire muscle group is by the facial nerve. To quote from Lightoller:

With the caput angulare pulling the ala nasi cranially and the pars alaris muscle nasalis pulling caudally and laterally the ala nasi, and caudally the inferior border of the nasal opening and septum mobile, we can see that the triangular exterior nares is very considerably modified in shape and made to approach the circular. This gives, of course, the greatest possible aperture.

From the above it follows that to increase the capacity of the nasal airway there is primarily a widening of the anterior nares and secondarily a widening of the post vestibular area. To decrease the capacity of the nasal airway there is a primary narrowing of the post vestibular area and a secondary narrowing of the external nares.

Depression of the nasal septum if it have any effect at all would rather be to widen the airway.

In forced or strained breathing the anterior and posterior dilator nares muscles are in a state of contraction so that, in addition to the aforementioned rounding, the nares are also slightly everted.

The pars compressor of the nasalis muscle, by controlling the space between the septum and the upper lateral cartilage, helps control the amount and the shape of the air current entering the nose proper.

It is at once apparent that since these muscles are so important in nasal physiology they must be visualized and their action understood when a rhinoplasty is being done. This can, in general, be best accomplished by always working close to the nasal framework.

As far as the innervation of the nose is concerned, there are three intranasal areas and three subcutaneous areas of importance in this

discussion Anesthesia applied to these areas is sufficient for the operations here discussed These areas are intranasally approximately at the anterior and posterior ends of the middle turbinate and at the nasopalatine foramen, subcutaneously the areas are at approximately the midpoints of the cephalad and caudad extremities of the nasal bone and at the infro-orbital foramen

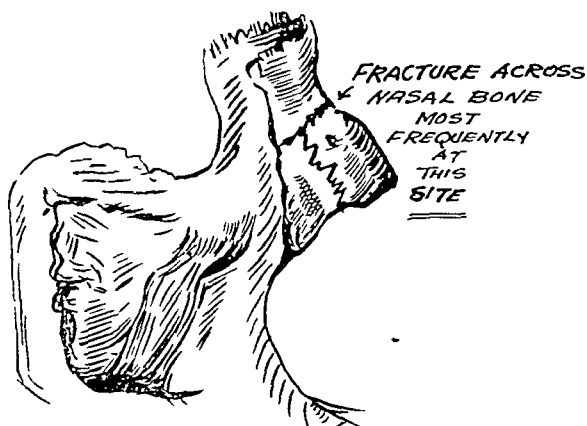


Fig 4—Type of deformity of nose and septum depends on direction and force of trauma

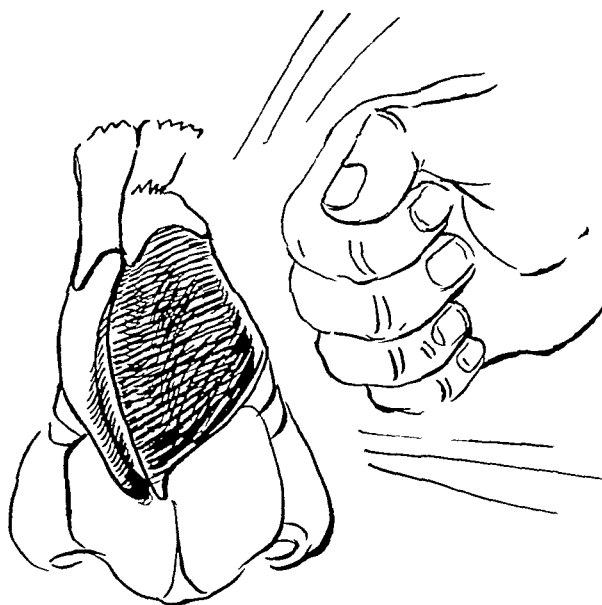


Fig 5—Deformity caused by lateral blow

#### EFFECT OF TRAUMA

The effect of trauma on the framework of the nose in general and on some of the structures in detail will now be considered

Figures 4, 5 and 6 show the result of injury to the nose (1) at the bridge, (2) at the upper lateral cartilages and (3) at the tip

A deviated septum or a deformed nose, or both, can interfere with the function of the nose. There are instances in which a submucous resection alone or a rhinoplasty alone will improve nasal function. There are other cases in which both operations are necessary before satisfactory results can be achieved. The rhinologist is therefore confronted, in each case that requires operative intervention, with the necessity of first making a decision whether to perform a submucous resection alone, a rhinoplasty alone or both a submucous resection and a rhinoplasty. If both procedures are necessary, shall the operations be done separately or both at one operative session? If done

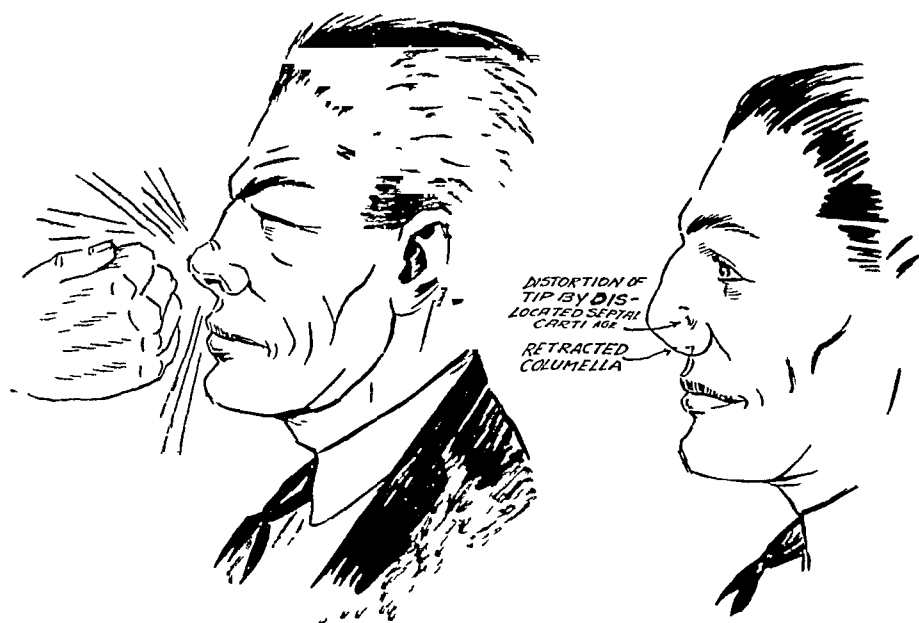


Fig 6—Dislocation of septum caused by trauma at the tip

separately, which operation shall be done first? It is my opinion that whatever decision is made should be based on a thorough knowledge of the anatomic derangement and physiologic dysfunction found in each case. One should then be guided by surgical judgment and experience rather than by rule of thumb in how best to repair the damage found.

How does one proceed to look for anatomic and physiologic abnormalities? First, one inspects the exterior of the nose during quiet breathing. Varying degrees of alar collapse during inspiration yield the following information:

- 1 The columella may be too broad and obstruct the nostril.
- 2 The nostril may be too narrow and slitlike and thus cause abnormal variations of pressure within the nostril.

3 The structures of the roof of the vestibule may be atrophic or inadequately supported

Then one examines the interior of the nose with and without mucosal shrinkage. This will yield much information familiar to the rhinologist.

When rhinoplasty is contemplated, a study of photographs of the face is important both for making a diagnosis of the type of nasal deformity and for achieving face balance. The set of photographs



Fig 7—Nostril view—dislocated septum before and after correction

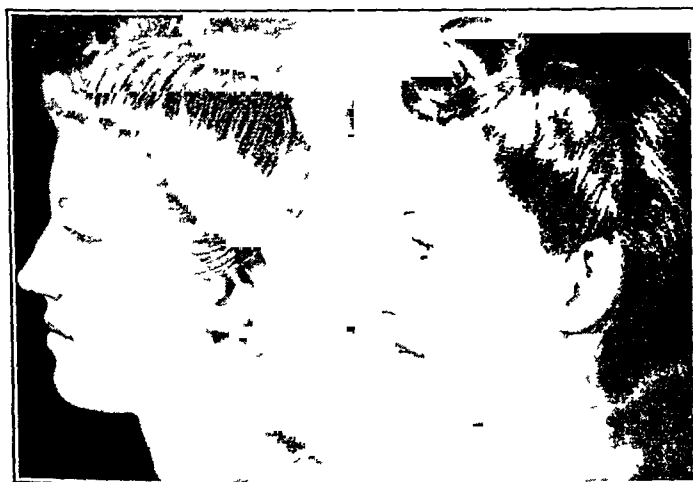


Fig 8—Profile view—deformity of nose and dislocated septum before and after correction. Note correction of retracted columella by use of columellar cartilaginous strut.

employed is taken as follows: (1) one full view, (2) both profile views and (3) one nostril picture taken from beneath.

Aufricht<sup>6</sup> suggests an extra set of pictures taken during laughter, for the reason that many deformities are then exaggerated. The photographs are usually printed one-half face size, except for the nostril

<sup>6</sup> Aufricht, G. A Few Hints and Surgical Details in Rhinoplasty, *Laryngoscope* 53 317-335 (May) 1943

view, which is made natural size. The face balance here described is that taught by Dr. Samuel Foman.<sup>7</sup>

In the full face view the nose normally occupies the middle third of the distance from the hair line to the bottom of the chin. At the alae the outer margins should fall within perpendicular lines dropped from the inner canthi. The midpoint of the root of the nose, the midpoint of the tip of the nose and the midpoint of the philtrum should be in the same perpendicular line. This perpendicular line should bisect the nose.

The profile angle of the nose should be about 30 degrees. The angle between the columella and the lip or the nasolabial angle should be about 90 degrees or more. In profile view the columella should extend slightly beyond the outer rim of the nostril.



Fig. 9—Same case as in fig. 8. Semiprofile view before and after correction. Note correction of hump and of cleft lip.

The nostril view yields information as to the width of the columella, the size and shape of the nostrils, the bulkiness of the tip and the flaring of the alae. A plan for the correction of any deformity and a pattern of tissues to be excised can be made from such a study.

A careful study of such photographs combined with a rhinoscopic examination helps one visualize what happened to the structures injured. With this knowledge one can better restore the structures to a normal appearance and therefore a normal function.

#### SEQUENCE OF OPERATION

Now, with knowledge obtained from the sources mentioned combined with a pertinent history, one can better decide on the sequence of operation when both a submucous resection and a rhinoplasty are indicated.

<sup>7</sup> Foman, S. Personal communication to the author.

1 A submucous resection should precede a rhinoplasty when a deviation of the septum exists with pathologic changes which may contraindicate a rhinoplasty, such as the existence of (*a*) purulent sinus infection which the septum does not permit to drain satisfactorily, (*b*) nasal polypi with chronic sinusitis or (*c*) thickening or deflections of the caudal half of the septum which may interfere with an adequate osteotomy

2 The submucous resection should be done after a rhinoplasty (*a*) when extensive shortening of the nose is necessary—one thus assures tip support, (*b*) when extensive removal of the hump is necessary—occasionally a high cartilaginous deflection may be simultaneously removed, and (*c*) when the upper lateral cartilages end short of the caudal end of the cartilaginous septum. One thus eliminates the danger of a saddle nose following a too thorough submucous resection distal to the upper lateral cartilages and then not having upper lateral cartilage long enough to repair the defect

3 A submucous resection must be done simultaneously with a rhinoplasty (*a*) when the septum is so thick at its ventral third that it interferes with adequate olfaction when the nose is narrowed, (*b*) when the septum makes infracture with adequate narrowing impossible, (*c*) when infracturing results in gaps created by a septum which is transverse to the midline and which cannot be forced into a midline position simply by thumb pressure, and (*d*) when a nasal deformity is accompanied with a dislocation of the septal cartilage which obstructs the nasal vestibule

For the correction of the septal cartilage which obstructs the nasal vestibule the Kayser procedure advocates in part the following (from Kayser's article<sup>1</sup>) If a hump is present, it is removed and

the upper lateral cartilages are completely freed from their septal attachments. One usually finds that as soon as the fragment of cartilage is liberated from its marginal attachments it is drawn into an unnatural position beyond the mid-line because of the scar contracture of the mucoperichondrium attached to the other surface of this cartilage fragment. It is in this instance that it is necessary to excise the deflected cartilage entirely. The mucoperichondrial flaps are undermined both from the remaining septum and from the floor of the nose until enough slack is created to permit the flaps to stay in the mid-line when complete healing has occurred. The upper lateral cartilages are then sewn together.

The operator knows that these upper lateral cartilages are themselves supported from the ental surface of the nasal bones. He must always insure adequate support of these nasal bones. Otherwise when a hump is removed and too much perpendicular plate of the ethmoid is taken away, the entire outer framework of the nose may collapse as soon as an osteotomy is completed. In some instances the upper

lateral cartilages themselves may be too inelastic or of poor consistency, so that in the judgment of the operator they may not be satisfactory for the support of the ventral aspect of the nose. In such instances the operator must improvise other forms of support.

Mention was made of the nasal musculature. When one understands the repeated pulls on the mobile septum and the alae caused by these muscles it becomes apparent how futile some sutures, such as the orthopedic suture, ultimately become.

#### CONCLUSION

Detailed knowledge of anatomy, experience and improvisation are the keystones for progress in surgery of the septum.

# Abstracts from Current Literature

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## Ear

EVALUATING THE EFFICIENCY OF GROUP SCREENING TESTS OF HEARING HAYES A NEWBY, J Speech & Hearing Disorders **13** 236 (Sept) 1948

The author describes a simple technic which can be applied in study of the efficiency of a group screening test. In examining the efficiency of a group pure tone screening test, the author tested every fourth child individually. The more subjects were tested individually, the better was the measure of efficiency obtained. No fewer than 50 subjects or 100 ears should be tested individually in any group. Newby found it useful to combine children of the eighth and seventh grades, those of the sixth, fifth and fourth grades, and those of third and second grades in a sampling test of group screening in the school system. A convenient method of examining graphically the data thus obtained is the use of a tetrachoric table. This table is used not to obtain a coefficient of correlation, but merely to portray the data in a meaningful fashion. Once a criterion of a significant hearing loss has been properly established, it is easy to adjust the efficiency of any group test by means of a tetrachoric table. If no amount of juggling of the criterion of significance of the group test results in reducing the percentage in any particular cell used to indicate success without raising the percentage in another cell used to indicate failure, then the group test is not operating with satisfactory efficiency.

PALMER, Wichita, Kan

MEDICAL TREATMENT OF MENIERE'S SYNDROME JOHN J RAINY, New York J Med **48** 1833 (Aug 15) 1948

Rainey reports excellent results in 83 per cent of 121 patients seen at Troy Hospital since 1940 who were treated with intravenous injections of histamine phosphate.

Attacks of Meniere's syndrome are said to be brought on by release of histamine from body sources. The syndrome is characterized by dizziness with a turning sensation, deafness in one or both ears, nausea or vomiting or both. It is a disorder of the vestibular labyrinth, for which the phrase "labyrinth hydrops" has been suggested. Rainey is opposed to use of that term. He states that the earlier the diagnosis is made and treatment is instituted, the more likely is recovery to be complete. In fact, "most patients get well with the passing of time." He reports 2 cases as representative of the group. About 1 patient in 7 requires intravenous administration of histamine. Three patients had resections of the auditory nerve, but only "improved" (in the presence of total deafness). One had had a nerve resection twelve years before, with return of symptoms five and one-half and twelve years later.

A salt-free regimen with ammonium chloride was of "no benefit." The newer drugs, diphenhydramine (benadryl®) and tripeleminamine (pyribenzamine®) should be used cautiously, as they may "confuse the issue."

Administration of histamine phosphate into a vein is time consuming, requiring from one and one-half to two hours. However, if the physician's diagnosis is correct, he will have in histamine phosphate used intravenously the best treatment at present available.

*Abstracter's Comment*—Some readers may criticize this laudatory report because of the apparent inconsistency between the statement that most patients



get well with any or no treatment, and that about 83 per cent get well with histamine technic. However, a desperate patient will demand that "something be done"

VOORHEES, New York

### Larynx

CONGENITAL MALFORMATION OF THE ESOPHAGUS WITHOUT TRACHEO-ESOPHAGEAL FISTULA JAMES R LISA AND HELEN M TAYLOR, New York State J Med 48 1622 (July 15) 1948

A boy, born Jan 25 1946, died in the fiftieth hour. The first feeding was given six hours after birth and was repeated, but with each there were cyanosis, gasping and regurgitation. Diagnosis at autopsy showed atresia of the middle third of the esophagus without tracheobronchial fistula. Acute bronchopneumonia was also present. A review of the literature shows that this condition occurs in 1 of 20,000 births (San Giovanni Maternity Hospital, Rome). At Bellevue Hospital (New York) only 1 case was found in sixteen years. At the City Hospital, Welfare Island, 3 cases were noted in 5,158 autopsies. The total reported number in the literature is about 400. "Total absence of the esophagus" has not been reported in the last twenty-seven years. There have been many cases of esophageal atresia without fistula. Heredity plays no part, but hydramnios should call attention to a possible congenital anomaly. Roentgenography is of value in outlining the upper pouch, taken with barium sulfate or iodized oil. U S P Furman recommended esophagoscopy without these agents. Surgery offers a chance, but attempts years ago were unsuccessful. Success depends on early diagnosis, prompt operation and avoidance of any complication, such as pneumonia. Stenoses may be dilated in older infants and children. The authors offer fifty-eight references from the literature.

VOORHEES, New York

### Nose

SOME PITFALLS IN SINUS SURGERY J JEROME LITTELL, Laryngoscope 58 396 (May) 1948

Otolaryngologists stand "before the bar of public opinion for [their] too frequent failure, in the past, to satisfy the patient that he has had a satisfactory degree of lasting improvement from surgery." Littell gives rules to be followed and factors to be considered in order to achieve satisfactory surgical results. Many of the sinus operations are discussed in the light of the mistakes that should be avoided and the results that should be attained.

HITSCHLER, Philadelphia

BENIGN CYSTS OF THE ANTRUM ORIGINATING FROM THE JAW OR TEETH W A NEWLANDS, Laryngoscope 58 402 (May) 1948

Newlands presents a comprehensive report on benign cysts of the maxillary sinus originating from the jaw or teeth. Their origin, classification, diagnosis (including roentgenologic), treatment and many other aspects are discussed in some detail. Two cases, one of a dentigerous and one of a radicular cyst, are presented, the difference between these two types is stressed.

Hitschler, Philadelphia

SURGICAL TREATMENT OF ETHMOIDITIS JAIME SALA LOPEZ, An de oto-rino-laring d Uruguay **17** 77, 1947

Sala Lopez discusses the anatomic problems involved in the treatment of acute and chronic ethmoiditis and presents a chronologic discussion of various operative procedures that have been advocated for control of these conditions. He states that one should remove the cause of insufficient drainage from the middle meatus. Whatever procedure is indicated should be resorted to, whether it be removal of the anterior portion of the middle turbinate body or a sub-mucous resection. These procedures should never be undertaken in the presence of an acute infectious process. If the ethmoid sinuses have become a septic cavity and have not been drained properly, they may act as a focus of infection. Proper drainage of these sinuses is always more advantageous than curettage, for after all, even though the ethmoid sinuses may be perfectly curetted, if drainage and aeration are insufficient they can always be a source of reinfection. The author believes that the transantral approach to the ethmoid sinuses assures an exposure for the most complete drainage, particularly when the posterior ethmoid and sphenoid sinuses are involved. This is also valuable in the cases of fronto-ethmoid sinusitis. He is of the opinion that an external approach should be used only if a transantral operation has not afforded sufficient drainage and aeration. Attention to the maxillary sinuses is of extreme importance, and treatment of these sinuses should be included with that of other sinuses involved.

PERSKY, Philadelphia

### Miscellaneous

RELATION OF DOSAGE TO STREPTOMYCIN TOXICITY RALPH TOMPSETT, Ann Otol, Rhin & Laryng **57** 181 (March) 1948

Streptomycin is a valuable agent in treating many acute and chronic infections for which no other drugs are available, but frequent and severe toxic reactions occur from its use, and it may produce rapid emergence of resistant strains of organisms. The diseases for which the drug is effective are, in general, serious infections with a high rate of mortality and for which no other effective antibiotic agent is available. Because of this and the knowledge that the organisms rapidly develop resistance to the drug, there has been a tendency to administer large doses of it. Also, it has been thought that, since the drug was so rapidly absorbed and eliminated and that maintenance of constant levels was necessary, frequent injections must be given. The author presents evidence that neither the frequent injections nor the maintaining of constant levels is necessary. His observations would suggest that the rational regulation of dosage schedules should be based on the body weight of the patient and that, probably, long intervals may be allowed between injections. The author discusses some of the various complications caused by the drug, including allergic manifestations. In 5 cases in which the latter appeared, therapy was able to be continued by the use of another drug, dihydrostreptomycin, which is closely related to streptomycin and which, so far as tested to the present time, appears to have similar antimicrobial activity. Organisms sensitive to streptomycin are also sensitive to this drug, and those resistant to one are resistant to the other.

M V MILLER, Philadelphia

REHABILITATION OF THE AURALLY HANDICAPPED THROUGH THE STUDY OF SPEECH READING IN LIFE SITUATIONS BORIS V MORKOVIN, J Speech Disorders **12** 363 (Dec) 1947

In training for speech reading, stress should be placed on the complete stimulus pattern rather than on the movements of the lips or other single items. Speech

reading is most successful when it is taught on the basis of life problems and the necessity for solving them. All the senses are interlocked in their modalities, and successful teaching is done by auditory-visual-kinesthetic cooperation. Motion picture films are helpful in teaching speech reading. Two illustrative cases are presented.

PALMER, Wichita, Kan

A PROGRAM FOR THE SPEECH-INHIBITED CHILD. AMY BISHOP CHAPIN and MARGARET CORCORAN, *J Speech Disorders* **12** 363 (Dec) 1947

The term delayed speech has been used too often to include all kinds of immature speech development. Subjects accepted for this study were screened by excluding the mentally deficient, autistic, prepsychotic children, children with cretinism and mongolism and children with deterioration and gross damage to the brain. The children selected, therefore, showed evidence of normal, intelligent behavior and passed all neuropsychiatric examinations with a diagnosis of some form of emotional-environmental retardation or suspected aphasia. Sixteen children were in the study, with an average age of 5.2 years. That the children were in a nursery school made it possible to overcome their fears and feelings of inadequacy and to develop social sufficiency. Speech was stimulated very carefully. Each child was addressed as though he were expected to talk. A great deal of work was done with the parents, explaining by lecture and individual conferences the problems involved. Of the 16 children, 12 were either dismissed as having attained normal speech for their age level or were accepted at regular schools. Two needs were discovered in this study: first, an adequate pamphlet for parents and, second, reliable diagnostic procedures. The author states that 45 per cent of children with so-called delayed speech referred to the clinic in a six month period had no endocrine disturbances and were not deaf, feeble-minded, autistic or prepsychotic, but were merely speech-inhibited normal children.

PALMER, Wichita, Kan

VISUAL AIDS TO SPEECH IMPROVEMENT. WILBERT PRONOVOST, *J Speech Disorders* **12** 387 (Dec) 1947

The author discusses the use of the oscilloscope for showing differences in rate, duration and pitch in speech. The oscilloscope is also used in some work with defective voices when too large a crescendo occurs, as in the "glottal attack." The voltmeter, decibel indicator and similar devices are useful in regulating volume. An apparatus which will measure nasality directly by activating an amplifier is mentioned, and a speech game for children, in which letters are mounted behind a bulb system with nine windows, is discussed.

PALMER, Wichita, Kan

THE WISCONSIN CLEFT PALATE PROGRAM. GRETCHEN MUELLER PHAIR, *J Speech Disorders* **12** 410 (Dec) 1947

The author reviews briefly the history of the incidence of cleft palate. In the state of Wisconsin, for a period of ten years, between Jan 1, 1935 and December 31, 1944, 1 case of cleft palate occurred in every 770 births. The percentage of births with cleft palate was greater for the nonglaciated areas than for the glaciated. A larger number of children with cleft palate were born during the summer season (July, August and September), than during the other months. The incidence of cleft palate increased slightly during the war years.

Mothers in the age group of 20 to 24 years produced many more children without cleft palate, while the groups of 35 to 39, 40 to 44 and 45 plus produced

proportionately more children with cleft palate. Cleft palate occurred more frequently in male children, there being 61.5 per cent of boys in the group. In the state of Wisconsin, out of 226 children with cleft palate, 97.3 per cent were twins, while only 2.15 per cent of the normal total live births were twins. A slightly higher incidence of cleft palate occurred in rural areas, and a higher percentage of cleft palate occurred in premature children. There is a slight tendency for the condition to occur more frequently on the left side.

Since 1943, a program of surgical correction, use of prosthetic appliances and orthodontic treatment together with correction of speech pathology, has been conducted in the Wisconsin Orthopedic Hospital. The Bureau of Handicapped Children in the State of Wisconsin has a medical social worker at the Wisconsin Orthopedic Hospital who handles the social problems which arise. A child welfare consultant works during the summer, finding boarding homes and supervising such social problems.

PALMER, Wichita, Kan

THE VETERANS ADMINISTRATION PROGRAM IN THE FIELDS OF AUDIOLOGY AND SPEECH CORRECTION. MERLE ANSBERRY, *J. Speech & Hearing Dis.* **13** 115 (June) 1948

Approximately 65,322 veterans of World War II with service-connected hearing losses or potential speech disabilities are now on the rolls of the Veterans Administration. Of all veterans drawing compensation for disabilities resulting from service in the recent war, 25 per cent have been adjudicated for hearing disabilities, 12 per cent of the same group have disabilities which make them potential candidates for speech rehabilitation. The Veterans Administration provides rehabilitation services through the Physical Medicine Rehabilitation Division and the Neuropsychiatry Division. Thirty contracts are at present in effect with professionally qualified speech clinics. The mental hygiene clinics of the Veterans Administration are also providing speech therapy by qualified persons. A training program is under way at Ohio State University and will be extended to other universities, probably in the near future, for qualified personnel in the field.

PALMER, Wichita, Kan

ALLERGY IN OTOLARYNGOLOGY. FRENCH K. HANSEL, *Laryngoscope* **58** 652 (July) 1948

A need exists for a method of treating hay fever that does not involve a long, and sometimes dangerous, series of injections. Each case must be studied individually. Diagnosis must include a careful history and examination, including the nasal secretions for the presence of eosinophils. Complete skin testing is necessary, and details are given explaining the procedure and the reactions to be expected. The coseasonal method of treatment (that of giving injections every one to three days during the hay fever season) is preferred by Hansel. Fewer injections are needed, and therefore no dangerous reactions are apt to occur. Oral administration of pollen extract instead of hypodermic injection is now being tried, with some success. No definite conclusions as to the exact efficacy of this treatment can as yet be drawn.

HITSCHLER, Philadelphia

# Society Transactions

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## CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

John R Lindsay, *President*

Lawrence J Lawson, *Secretary*

*Regular Monthly Meeting April 5, 1948*

**The Development of the Auditory Ossicles and the Temporal Bone** A Summary of Research Presented by BARRY J ANSON, PH D, of the department of anatomy of Northwestern University Medical School

Various phases of our otologic investigation, pursued divisionally, have already been described in a series of journal articles. Now we are able to correlate the once separate parts of the study and, as a consequence, to report on crucial steps of the development of the ossicles, of the otic capsule and of the extracapsular portions of the temporal bone.

Our observations are based on a study of approximately 300 series, chiefly in the collections at the University of Wisconsin and at the Northwestern University Medical School.

In general it may be said that maturity of gross form and size and of histologic structure is attained by the ossicles and the otic capsule far earlier than was once supposed. In fact, their development is so rapid that adult dimensions and configuration of the ossicles and the capsule are attained when one might expect them to be fetal. Equally remarkable is the fact that morphogenesis takes place in such a way as to violate some of the important conventions of the ossification process.

At 25 mm (or 8 weeks) the cartilaginous stapes is still a ring. At 50 mm (11 weeks) the features of a stirrup are acquired. At 126 mm (17 weeks) the base is marginally lipped, the head foveate so that it may articulate with the incus, the posterior crus longer and bowed—features which foreshadow adult configuration even before ossification has begun.

In the 150 mm fetus (20 weeks) the single center of ossification has appeared on the obturator surface of the base. At 160 mm bone has spread across the base, but not across the neck of the stapes. Concurrently, newly formed bone is being removed on the inner, or obturator, surface, but remains intact on the outer aspect. Erosion is deep, into the calcified cartilage. Bone continues its advance, forming a complete ring by the 180 mm stage (23 weeks). Since no epiphyses occur, no further growth takes place, adult size has been attained. However, removal of bone continues. Within another month and a half, that is, in the 245 mm fetus (29 weeks), mature form is virtually acquired.

It is essential to keep in mind the steps in the morphogenesis of a typical long bone. A human tibia will serve as an example. The cartilage "model" of a tibia suggests in a general way the form of the future bone. A shaft, or diaphysis, ends in slightly enlarged extremities which are the future epiphysal areas. Ossification begins in the diaphysis, to produce an elongate collar of bone. Externally, through activity of the osteoblasts in the periosteum, the enveloping shell of periosteal bone lengthens and thickens. Internally, spicules of endochondral bone and associated marrow tissue replace the original cartilage. At this stage bone formation is

augmented by an auxiliary histologic mechanism for longitudinal growth, namely, the secondary ossification center. One center appears at birth, the other soon thereafter. In both, cartilage persists as a growing plate—distally until the person is 17 years of age, proximally through the nineteenth to the twenty-third year. When cartilage is replaced by bone, growth ceases. Cartilage remains only on the articular surface of each extremity. Thus it is that a tibia grows steadily until the person has reached manhood. In an adult person the tibia is thirty-six times as long as it was when it made its first appearance in cartilage.

A stapes differs strikingly in structure from a long bone. Its ossification takes place from a single center, once formed in bone, it does not become thicker—there being no external application of bone to the periosteal layer, negligible production of endochondral bone internally, the stapes does not lengthen after periosteal bone has become continuous around the obturator foramen (in the fifth month), there being no epiphysial, or secondary, centers for growth, unlike a typical long bone, one wall—that facing the obturator foramen—is removed continuously in the capital, crural and basal portions of the stapes, marrow in what would be the shaft, or diaphysis, of a long bone is completely removed and is replaced by mucous membrane and submucosal tissue. Thus, while a tibia continues to grow into the period of early manhood, the stapes attains adult dimensions before the fetus has reached the halfway mark in its intrauterine existence. Within another two month period thereafter the stapes attains adult form. Whereas a tibia becomes progressively heavier while it is maturing, into the twentieth year, a stapes loses bulk while attaining maximum dimensions and adult form in the fetus. A stapes is far less robust as a mature ossicle than it was as fetal cartilage.

The bony otic capsule differs from other bones in respect to form, structure and function. It houses the sensory organs of hearing and equilibrium. It is capsular, that is, a box, being, in the adult, a single bone (therefore unlike the cranium which is made up of many elements separable at the sutures). Unlike cartilage bones, it has ossification occurring at various sites—a total of fourteen. These centers ultimately fuse so completely that the lines of original junction are virtually lost.

The otic capsule is composed of three layers of bone, namely, the periosteal (outer), the endochondral (middle layer) and the endosteal (internal layer, surrounding labyrinthine spaces).

The middle layer of the capsule differs from that of a typical long bone in containing numerous small remnants of modified cartilage which remain prominent through life, these islands of modified cartilage, later surrounded by endochondral bone, are the so-called intrachondrial bone. Cartilage persists also as a partial lining of the fissular tract anterior to the vestibular window (*fissula ante fenestram*) and for the inconstant tract of shorter course situated posterior to the window (*fossula post fenestram*).

In a tibia much of the endochondral bone gives way to marrow, in the petrous part of the temporal bone, on the contrary, little or no marrow is found. In the petrosa portions of the fetal cartilage are converted into intrachondrial bone and are retained in this form.

The development of endochondral bone, of the periosteal and endosteal layers, and of their predecessor, cartilage, will now be described as encountered in a series of five selected stages in the morphogenesis of the otic capsule.

In the 126 mm fetus (16 weeks) the capsule is still entirely cartilaginous. In the 183 mm fetus (21 weeks) cartilage is present at the posterior portion of the canalicular capsule and around the *fissula*. Endosteal bone forms a thin shell for the labyrinthine spaces (cochlea, vestibule and semicircular canals), this layer

undergoes no further growth, since no epiphysial areas exist. Periosteal bone is peripheral, on the cranial and tympanic walls. Intrachondrial bone occurs between these, representing the middle layer, it possesses a spongy appearance, as there is more space than bone.

At 270 mm (30 weeks) periosteal bone is a thickening stratum. It spreads to invade the canalicular part of the capsule. Endochondral bone now makes its first appearance—in the region of the superior semicircular canal. It begins to cover in the intrachondrial bone of the primordial osseous capsule. Destruction of the recently formed periosteal bone has begun (in the canalicular region), the mucous membrane of the antrum is already replacing osseous tissue and associated marrow.

In the term fetus the periosteal layer is thick in the cochlear region. Intrachondrial bone in the same region is reduced in relative amount as "replacement" (endochondral) bone is deposited on the intrachondrial spicules. Endosteal bone is unchanged. Through the formation of the endochondral bone marrow space has been reduced, relatively, forecasting ultimate fusion of the two osseous strata.

In an adult of 65 years periosteal and endochondral, or "replacement," bone together make up almost the total bulk of the capsule and of the bone deposited thereon. The replacement bone is a combination of the intrachondrial and endochondral types, the former (intrachondrial) formed the "skeleton" on which the latter (endochondral) has been deposited. In the adult the intrachondrial bone persists, but the surrounding endochondral bone, now more abundant, has virtually obliterated the marrow spaces. This middle layer can be distinguished from the outer stratum.

All these changes take place without increase in dimensions of the capsule, after the five month stage. The endochondral bone is not destroyed internally, to be reformed progressively, it remains virtually unaltered. However, periosteal bone does thicken, deposited on the capsule, it embeds the latter in extracapsular osseous tissue—to increase the dimensions of the so-called petrous part of the temporal bone, and to bring to the latter the form it here presents.

The periosteal bone of the late fetal and the infantile ear does not long remain intact. In the fetus of 260 mm (29 weeks) the advancing epithelium has reached the mouth of the developing antrum. Invasion is rapid, spread taking place from the tympanic cavity and the auditory tube, to surround (in some specimens) the carotid canal, to reach the apex of the temporal bone and to occupy the former site of bone between semicircular canals—thus displacing not only periosteal bone of extracapsular position but also some of the endochondral bone of the capsule itself, the original capsular tissue tending to remain intact. Pneumatization, in some specimens, is complete at the age of 3 years or earlier.

In the otic capsule the first of a total of fourteen ossification centers appears early in the fourth lunar month (120 mm). Soon three are present. Others appear in rapid succession, enveloping the labyrinth, replacing cartilage. They have fused to form a complete box, or capsule, prior to the middle of intrauterine life (183 mm). Thus, adult dimensions are attained at the same time that the stapes attains full size. In a short period of five weeks the osseous capsule has been formed. Growth is prevented by fusion of the numerous centers of ossification (without intervening zones of epiphysial nature) and by concomitant formation of endosteal shells for the canals and cochlea.

Thus, although the otic capsule of the midterm fetus is as large as it will ever be, it is neither histologically mature nor is it yet embedded in the extracapsular osseous tissue whose outline lends the typical form to the so-called petrous part of the temporal bone. In the core of the capsule, between periosteal and endosteal layers where marrow might be expected to occur, bone of endochondral character

is deposited on remnants of persistent, changed, cartilage. Once formed, such tissue is not removed as it would be in a typical long bone, to make way for marrow. When removal occurs, it is to permit mucous membrane to spread from the tympanic cavity or the auditory tube into part of the capsule. Concurrently, periosteal bone—added to the capsule in the latter half of fetal life—is similarly invaded to form the cells of the apical and related portions of the temporal bone.

## DISCUSSION

DR ELMER W HAGENS. Dr Anson has given the members of this society another of his illuminating papers on developmental anatomy of the ear. As otologists the members are fortunate in having in their midst someone who is not only capable but sufficiently interested to give them the results of his research in their field.

Some years ago I had the opportunity of studying the development of the human ear in a group of fetuses at the University of Chicago. My series was not nearly so complete as Dr Anson's, nor did I have the opportunity to study the material in detail. However, I did find many of the structures he has mentioned, and can appreciate the labor and the care that has gone into his investigation. A number of the facts brought out may have a relation to clinical findings. For example, in the early stages of the development of the stapes the head is connected with the hyostapedial tissue from which the stapedius muscle and tendon are derived. In 1 of 4 cases of malformation which I have studied, the malleus, the tensor tympani muscle and the incus were present while the stapes and the stapedius muscle were absent. In a second case the malleus, the tensor tympani muscle and the incus were absent, while the stapes and the stapedius muscle were present. These findings can be correlated with the development of the ossicles as presented by Dr Anson. Cases have been reported of malformation of the stapes, such that only one incus extending from the center of the footplate was found. I wonder if Dr Anson has any idea as to how this could occur. I believe his finding of the double origin of the stapes is an important contribution, it makes the development of this ossicle much more understandable.

In development of the ossicles it is noted that the malleus and the incus contain marrow, while the stapes when fully developed does not. In examining sections of the temporal bone having a history of otitis media, I have found infection extending into the marrow cavity of the incus from the tunica propria of the mucosa. In other sections the stapes is found completely embedded in infected tissue, but the outlines of the ossicle can still be seen. Owing to the difference in anatomy, infection may affect the malleus and the incus in one manner and the stapes in another. Otosclerosis frequently involves the stapes, whereas, except for one or two reports in the literature, otosclerosis has not been found in the malleus and the incus. Whether the anatomy of the particular ossicle has anything to do with this is problematic, but one may speculate on it.

Study of the three layers of the bony labyrinth has assumed increasing importance because of the fenestration operation. Experiments are going on at present as to the best method of making the fenestra remain open, but the final solution is yet to come. Careful studies such as these of Dr Anson's may reveal clues that will help in finding the answer to the problem of the closure of the fenestra.

It is interesting to note that while the petrosa is different from all other bones in that its enchondral layer contains cartilaginous rests and other islands of cartilage, yet this is the layer where otosclerosis usually begins. Furthermore, otosclerosis does not occur in other bones, nor has it been found in animals. Dr



Bast, one of Dr Anson's co-workers, has found the fissula ante fenestram only in the human temporal bone, also, he has noted that otosclerosis, starting at the "site of predilection," begins in the secondary cartilage formation about the fissula. Finally, the fissula becomes obliterated and, he feels, this may possibly produce deafness by obstructing the perilymph-filtering function of the fissula. Thus one finds otosclerosis—which is found only in the human patient and only in the temporal bone—beginning usually in tissue about the fissula ante fenestram, which is, itself, found only in the human being.

Whatever the true relationship and importance of these findings may be, it is evident that studies of the temporal bone such as these are of great interest to otologists, and may well lead the way to a solution of some of their baffling clinical problems.

**DR BARRY J ANSON** In addition to thanking Dr Hagens for his generous comments, I should like to emphasize one point. From the developmental standpoint the ossicles should not be regarded as bones which follow similar patterns of morphogenesis. The malleus and the incus resemble a miniature tibia, their developmental schema matches that of a typical long bone, despite the fact that they are derived from the branchial arch skeleton. The stapes, although likewise originating at least in part from an arch, does not conform to the "standard" pattern. The stapes (closely related in its basal portion to the otic capsule) undergoes profound alteration in form after it has been fully developed in cartilage, the bone of the ossicle is removed continuously on the obturator aspect with, concurrently, negligible production of intrachondrial bone within its crura. It loses approximately one half of its bulk while attaining adult form and size in the fetus. Its unusual developmental history would be expected to make a difference in any pathologic change which it might later manifest.

**Intranasal Medication with Vasoconstrictors** Presented by **DRS O E VAN ALYEA AND ALLEN DONNELLY**, of the department of otology, rhinology and laryngology of the University of Illinois College of Medicine

An investigation was carried out at the Research and Educational Hospitals, of the University of Illinois, to determine the effects of nasal vasoconstrictors in cases of hypertensive, cardiac and thyroid disorders and diabetes mellitus. This investigation was prompted by the fact that the Federal Food, Drug and Cosmetic Act requires a "warning" on bottles containing ephedrine or vasoconstrictors of similar character. This warning reads: "Caution. Frequent or continued use may cause nervousness, restlessness or sleeplessness. Individuals suffering from high blood pressure, heart disease, diabetes or thyroid trouble, should not use this preparation except on competent advice."

This study was made on 11 patients with hypertension, 16 with cardiac disorders, 9 with thyroid disorders and 14 with diabetes. After a complete examination, the patient was placed in the head-low position on an examining table, and 5 drops of a vasoconstrictor was instilled into each nostril. The position was maintained for several minutes, then the patient was returned to the sitting position. Pulse and blood pressure readings were made at intervals up to forty-five minutes. The testing solution applied was one in common use, "neo-synphrine hydrochloride" (phenylephrine hydrochloride N N R) in the strengths of 1 per cent and 0.25 per cent.

**Results**—No untoward effects were noted, and it was thought by the investigators that absorption from the nasal membranes is entirely too retarded to be of consequence in the development of side effects, and that when such do occur it

could be assumed they were due to drugs that had been inadvertently swallowed and absorbed from the stomach

In view of this probability and the results of the present investigation it is felt by the writers that in the intranasal application of vasoconstricting solutions no distinction need be made between patients who have and those who do not have organic disorders and that the warning called for by the Federal Food, Drug and Cosmetic Act is unwarranted. A substitute warning, should one be required, could well read "For nasal medication only Do not swallow"

#### DISCUSSION

DR CARL C PFEIFFER This courageous study by Dr Van Alyea and his associates is meritorious and should be called to the attention of the Food and Drug Administration. They are a relatively small scientific group in Washington, they do not have on their staff any member of a specialty group such as this, they cannot make experiments. They may consult experts, but sometimes these may fall within the definition of an expert consultant for the Army, namely, "any S O B from out of town". Nevertheless, one must point to the good things they have done. They have been instrumental in stopping the marketing of vasoconstrictors suspended in liquid petrolatum. They have prevented the toxic effects of many other drugs which would have been foisted on the unsuspecting public. They are not concerned with the therapeutic merit of a drug, only with its possible toxic effect.

With regard to nasal vasoconstrictors, the history of the use of these compounds has been rife with minor toxicity. Physicians know that epinephrine produces a reactive hyperemia which is worse than the primary condition. They know that "argyrol" (mild silver protein U S P) may produce argyria and that it will also destroy the cilia of the nasal mucous membrane. They know that the use of ephedrine in oil may give rise to lipoid pneumonia in children when the oil drains into the lung. They know that nasal vasoconstrictors, particularly eucalyptus oil or menthol, will congest the nasal mucous membrane. "Chloretone" (chlorobutanol U S P) paralyzes the nasal cilia. So there are still harmful medications on the market. The use of "privine hydrochloride" (maphazoline hydrochloride N N R), as Dr Van Alyea said, may produce reactive vasodilatation. Amyl nitrite or organic nitrites when applied to mucous membranes are promptly absorbed, but with the water-soluble vasoconstrictors there is decreased blood supply, and little is absorbed in the mucous membrane. The greatest systemic danger comes from swallowing vasoconstrictor compounds which are not destroyed in the stomach, phenylephrine is, ephedrine is not. Physicians have looked for vasoconstrictors which are without central stimulation.

Dr Van Alyea's study has gone a long way in reassuring otologists that vasoconstrictors can be applied to the nasal mucus membrane without fear of complications as long as they are not swallowed. If this study is brought to the attention of the Food and Drug Administration, they will undoubtedly modify their labeling requirements.

DR ALFRED LEWIS In view of the fact that one proprietary product was brought out prominently in this investigation and, further, in view of the fact that Dr Pfeiffer has mentioned two others as having similar effects, I should like to ask if he has a more complete list of proprietary drugs that can be used without danger of their being absorbed from the stomach or of central stimulation. If one goes into the matter of proprietary medication at all, I do not think one should advance any product above another.

DR JOHN R LINDSAY Dr Van Alyea has mentioned that many patients have suffered from the prolonged use of "privine" It would seem reasonable that the authorities should warn against using such a drug for prolonged periods except under the advice of a physician

DR CARL C PFEIFFER Most of the proprietary products that are not specialties of given pharmaceutical houses contain an ephedrine salt, 1 to 3 per cent, 5 drops of a 3 per cent solution would provide about 10 mg of the ephedrine salt, and, if applied often, would be an effective systemic therapeutic dose Except for epinephrine, the only nasal constrictor which is now known to be destroyed to any extent in the stomach is "neo-synephrine hydrochloride" (phenylephrine hydrochloride N N R) It is true that Frederick Stearns & Company Division had an elixir of this drug which they marketed, but this has been ineffective Even their neo-synephrine hydrochloride solution supplied in ampules for intramuscular injection will be destroyed within a short time if any metal comes in contact with it This occurs the first time a hypodermic needle is used to remove a dose from a vial So vials of this solution should not be used for more than one or two weeks That is true also of the metal atomizer, the active substance will be slowly destroyed unless an all glass atomizer is used

DR O E VAN ALYEA As I mentioned in the paper, this is not a complete study We hope to carry out a similar investigation using ephedrine I doubt that we shall use "privine," but I think we should use ephedrine The paper was not intended to impress the Federal Food, Drug and Cosmetic group, but we thought it a subject which would be good for investigative purposes in view of our experience with drugs applied locally in the nose

### Hand-Schuller-Christian Disease and Eosinophilic Granuloma of the Skull

Presented by DR HAROLD F SCHUKNECHT, of the department of otolaryngology of the University of Chicago

Eosinophilic granuloma, Letterer-Siwe disease, and Hand-Schuller-Christian Disease are now considered to be closely related conditions They are thought to be clinical gradations of expression of a common basic disorder There are two theories as to their cause, one holds that there is a disturbance of lipid metabolism, whereas the other regards the disturbance as an infectious process

Letterer-Siwe disease is a rare, rapidly fatal form occurring before the age of 2 and is of little clinical significance to the otolaryngologist Hand-Schuller-Christian disease is a less severe form of the disorder, having a 30 per cent mortality The destructive skeletal lesions which characterize this disease commonly attack the base of the skull, consequently the temporal bone is frequently involved Initial symptoms of the disease therefore may be aural disturbances As the lesion of the temporal bone grows in size it may manifest itself in several ways (1) by perforation of the external wall of the auditory canal, (2) by erosion of the cortex of the mastoid process or of the zygomatic or the squamosal portion of the temporal bone, (3) by invasion of the labyrinthine capsule, (4) by involvement of the facial nerve, (5) by encroachment on structures in the jugular foramen, (6) by secondary infection

Granulations appearing in the canal of the external ear in the presence of a destructive lesion of the mastoid process and an intact tympanic membrane are suggestive of this disease The diagnosis can be made by microscopic examination of this granulation tissue

Secondary infection frequently occurs in such a diseased temporal bone In that case the underlying disease is often overlooked An important clue is the

roentgenographic evidence of a destruction of bone out of all proportion to that which one would expect from the duration and the degree of infection. When the diagnosis is suspected, it is important to seek roentgenographic evidence of other skeletal lesions.

Eosinophilic granuloma is a benign form of the disease which manifests itself by one or a few skeletal lesions. The skull is a common site for solitary lesions. As in Hand-Schuller-Christian disease, there is usually little accompanying pain. The diagnosis of Hand-Schuller-Christian disease and eosinophilic granuloma must be made by microscopic examination of involved tissue, as there is nothing about the roentgenographic or clinical pictures which will differentiate these diseases from each other or from several other conditions.

The histopathology of the disorder is basically that of an inflammatory histiocytosis. In Letterer-Siwe disease there is marked proliferation of histiocytes in involved bone and many viscera, with varying degrees of superimposed acute inflammatory reaction. In Hand-Schuller-Christian disease the lesions have accumulations of histiocytes, which are usually filled with lipid material. The lesions of eosinophilic granuloma are characterized by sheets and strands of histiocytes throughout, which are conspicuous collections of eosinophils. The individual lesions of these diseases respond well to roentgen ray therapy. After the diagnosis has been established by biopsy, roentgen ray therapy should be instituted.

Mastoidectomy should be done only to treat temporal bone lesions which are infected, or when it is necessary to obtain tissue for biopsy. In cases of these diseases mastoidectomy wounds heal slowly unless followed by roentgen ray therapy. Mastoidectomy was performed in 2 of 3 cases of Hand-Schuller-Christian disease of the temporal bone. In 1 the diagnosis was established by microscopic examination of granulations appearing in the canal of the outer ear. The region of the frontal bone immediately above the lateral aspect of the supraorbital ridge appears to be a common site for solitary eosinophilic granuloma. In 1 patient a chocolate-colored cyst with granulation tissue walls was encountered in that area. Such a lesion may represent an eosinophilic granuloma in a late phase of central degeneration, hemorrhage and scarring. Another patient had a large eosinophilic granuloma of the mandible.

All these solitary lesions were removed surgically. Roentgen ray therapy is an equally successful treatment. Common procedure is to establish the diagnosis by frozen section biopsy and to curet away the lesion during the same operative procedure. Should other skeletal lesions appear they can be treated with roentgen radiation.

#### DISCUSSION

DR H B PERLMAN. From a purely clinical standpoint experience emphasizes that it is easy to overlook the true nature of the lesion, especially when infection is superimposed. This was true in all the cases involving the ear which have come to my attention. The first 2 patients were operated on, and some of the removed material was examined histologically without anyone's recognizing the underlying disease process. The original impression was that of ordinary inflammatory granulation tissue, only after other lesions of bone developed was the original lesion of the mastoid process suspected. Then a careful search through all the histologic material removed at the time of operation revealed the characteristic picture in areas not directly involved in the acute inflammatory response. This indicates that in the presence of an infected lesion all the tissue removed must be carefully examined, preferably by a trained pathologist who is familiar with the histologic variations in different phases of this disease. The fact that the original lesion of the ear may have healed and that the patient may have been discharged

before a lesion develops elsewhere in the body also contributes to inaccurate diagnosis. Considerable time may elapse before a new lesion develops, and the patient then seeks relief of shoulder pain, for example, because of a lesion of the scapula. Superimposed infection of a lesion, especially when complications are present as in the first 2 cases in which the mastoid process was involved, requires complete surgical extirpation.

In the presence of noninfected lesions, however, as in the third case in which the ear was involved, complete operative removal is contraindicated and can be prevented if tissue is available for histologic examination. Involved tissue may be obtained easily if the lesion is in the canal of the external ear, as in one case, in other cases biopsy of the mastoid process may be required. This lesion is sensitive to roentgen irradiation and begins to heal shortly after administration of a small dose. This response can be helpful for differential diagnosis. Even the noninfected lesions may produce a picture resembling that of simple suppuration. Thus, a youngster brought in because of a discharging ear was treated as having simple suppurative otitis both by the pediatrician and by the otologist for several weeks. Recurrent aural granulation and a full red drum membrane without landmarks were apparently compatible with such a diagnosis. However, careful examination while the patient was under anesthesia for removal of the granulation tissue failed to reveal perforation of the drum. The source of the granulation tissue was found to be a defect in the floor of the bony canal just external to the drum. The opposite drum membrane was full, red and devoid of landmarks, but there was no discharge or granulation tissue in that canal. Roentgenograms of the mastoid processes were made and were reported by a junior roentgenologist as showing simple bilateral clouding of small cells of these processes. Actually they showed such extensive change in density far beyond the limits of both mastoid processes that it was considered as normal background, against which the involved dense bone of, and adjacent to, the capsule was viewed. Of course, it is easy to look back after the diagnosis is made and point to the features of the case which set it apart from an ordinary case of otitis media. Insidious, painless onset and recurrent abundant granulations are significant.

Many diseases have to be considered in differential diagnosis. In a child recently examined, extensive destruction of the base of the mastoid bone in relation to the jugular foramen with paralysis of the seventh, tenth and twelfth nerves was due to a nerve cell tumor. A biopsy could be made through the floor of the external canal, into which the tumor had grown.

The whole group of apparently related diseases considered in this presentation is poorly understood. They appear to be, at least in part, concerned with disorders of fat metabolism. Enzyme systems of the cell controlling this fat metabolism are probably involved. Perhaps some of the newer histologic technics for demonstrating the effect of some of these cell enzymes may throw light on this aspect of the problem.

However, there are features that suggest that one is dealing with an infectious process. Further information might be obtained by exhaustive study of the material removed from a noninfected lesion such as one sees in the calvarium or near the frontal sinus. Complete aerobic and anaerobic cultures should be made of this material and it should be inoculated into eggs and into the anterior chamber of the eye. There should also be preparations of sterile extracts for skin testing. Any one preparing to operate on such a lesion should mobilize the resources of the departments of bacteriology and pathology for this type of study.

DR LAWRENCE J LAWSON. I wish to present briefly the record of a woman aged 51, the progress of the disease is readily shown in the seven slides presented

The right eye was glaucomatous and had a cataractous lens, so that it was impossible to see the fundus. The left fundus was anemic, and there were several episodes of dimming of vision. This was followed by complete blindness and atrophy of the optic nerve. There was complete loss of hearing in the right ear and about 80 per cent loss in the left ear. The patient's adherence to Christian Science interfered with observation and therapy.

The seven slides demonstrate the progress of resorption of bone in the pituitary region and the right temporal bone in a typical instance of Hand-Schuller-Christian disease. The first slide shows marked thinning of the posterior clinoid processes. In the following six slides, progressive destruction of the sella turcica, the clinoid processes and the posterior walls of the sphenoid sinuses is seen. Currently there is progressive resorption in the right temporal bone.

There was confusion in the early stages regarding the diagnosis. It was first believed to be a pituitary adenoma. The right eye was glaucomatous, and a consulting ophthalmologist strongly considered the presence of intraocular tumor with intracranial extension. Another consultant felt that it must be an intracranial extension of a nasopharyngeal transitional cell carcinoma. High voltage roentgen ray therapy was given. The patient has remained well nourished. She is blind and deaf. No recent roentgenograms are available at this time.

DR ELMER W. HAGENS. I should like to record the case of a child 22 months of age who was brought into the clinic at Northwestern University Medical School with a history of recent indefinite discharge of one ear. A large polyp was found blocking the external auditory canal making it practically impossible to see the drum. A roentgenogram showed a definite punched-out area in the region of the mastoid process with the report that, while the roentgenologist was not sure of its significance, the observation was unusual. It was treated as mastoiditis, and at operation it was decided to take out the polyp first. This growth proved to originate on the posterior wall, and the drum looked intact. One pediatrician had said that he incised the drum. After removal of the polyp, when the mastoid process was examined, no cortical bone was found, there was a grayish white tumor, which was enucleated as carefully as possible. The bone over the sigmoid sinus was gone, also that of the posterior wall of the external canal down to and including the anticus tympanicus. The tissue apparently went down to the seventh nerve, but a line of cleavage was made superficial to the canal of the facial nerve. Most of the tissue was removed, leaving a little over the sigmoid, the sinus was normal except where the tumor was attached. The wound was closed and healed well and promptly, facial paralysis developed the next day, which has now pretty well cleared up.

Our pathologist at Wesley Hospital has written an article on eosinophilic granuloma, and he believes that is what was present in this case. We hope the child will get along with roentgen ray treatment. This is the only lesion that is apparent. We were glad we did not go too close to the facial canal, because apparently the tissue was in contact with the facial nerve. No particular infection was noted, the polyp was apparently part of the process which had grown through into the external canal. Bacterial studies were not significant, and when we considered them with the pathologic diagnosis we felt that the area was not infected. It is easy to assume that one is dealing with mastoiditis, especially if a polyp is present and yet such cases can prove to be cases of tumor.

DR M. A. GLATT. About four years ago I presented a case of xanthoma-lipoid granuloma of the temporal bone before this society and discussed the difficulty of preoperative diagnosis when the symptoms involve only the temporal bone. In the presence of suppuration such a lesion often resembles *Pneumococcus* type III

infection If suppuration is absent, it is difficult to differentiate the lesion from cancer, tuberculosis or other types of bone disease

In the young, when the lesion of the skull has been associated with signs pointing to involvement of the pituitary gland, it has been known as Hand-Schuller-Christian disease None of these authors had a knowledge of the pathologic aspects of the disease Fundamentally, it is a disturbance of the fat metabolism in the affected reticuloendothelial cells which form the granuloma and is not caused by a disturbance of the general fat metabolism Such a disturbance can involve any organ of the body Customs and traditions are not easily discarded, and thus it becomes difficult to dissociate xanthoma of the skull from Hand-Schuller-Christian disease even though the pituitary symptoms, the most important, are absent

The essayists are fortunate in having had the opportunity to see such a large number of cases, as they are extremely rare in ordinary practice In presenting the first phase of the disease as eosinophilic granuloma they appear to have given a study of an extremely early stage, which possibly presents few symptoms However, the later phases, as described by them, and the final phase of fibrosis seem to add to the confusion already existing in classification I should like to see it more clarified and simplified

DR HAROLD F SCHUKNECHT (closing) In all the cases of eosinophilic granuloma the lesions were treated surgically, roentgen irradiation is an equally good treatment Common procedure is to establish diagnosis by frozen section biopsy and to curet away the lesion at the same operation Lesions which develop subsequently can be irradiated

Dr Lawson's patient with an extensive lesion of the base of the skull probably had Hand-Schuller-Christian disease The term "eosinophilic granuloma" should be reserved for those lesions having a milder course and consequently a better prognosis

A monosymptomatic early stage of Hand-Schuller-Christian disease has been known to exist for many years Several reports on solitary granulomas appeared in 1940, and since then the descriptive term "eosinophilic granuloma" has been in common use In 1942 the relationship of these granulomas and Hand-Schuller-Christian and Letterer-Siwe disease was emphasized by several investigators In Dr Hagen's patient there was a destructive lesion of the mastoid process, an intact tympanic membrane and granulations in the external canal Two of my patients presented similar findings Hand-Schuller-Christian disease is always suggested by this clinical picture The bony facial canal is often eroded away in such cases Surgical treatment of the mastoid process in these cases is best directed only at establishing diagnosis by biopsy or at treatment of complicating infections Complete curettage is hazardous, roentgen ray therapy is the treatment of choice

There is nothing about the roentgenographic appearance of the lesions of eosinophilic granuloma or Hand-Schuller-Christian disease which will differentiate them from each other or from several other conditions In differential diagnosis one must consider primary and metastatic carcinoma, primary and secondary cholesteatoma, osteomyelitis, multiple myeloma, tuberculosis, syphilis and fundus lesions I believe, Dr Glatt, that there is fairly universal agreement that these diseases are all manifestations of a common disorder Improvement in terminology probably must wait until the cause is discovered

## **News and Comment**

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### **ANNUAL MEETING OF OREGON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY**

The tenth annual spring postgraduate convention will be held in Portland, June 19 to 24, 1949. Another fine program has been arranged by the Oregon Academy and the University of Oregon Medical School. There will be four guest speakers—men outstanding in their respective fields. Dr. Lawrence R. Boies, professor of otolaryngology, University of Minnesota Medical School, Minneapolis; Dr. Leland Hunnicutt, associate clinical professor of otolaryngology at the University of Southern California, Los Angeles; Dr. James H. Allen, professor of ophthalmology at the Iowa State University School of Medicine, Iowa City; and Dr. Edmund B. Spaeth, professor of ophthalmology at the University of Pennsylvania Graduate School of Medicine, Philadelphia.

There will be lectures, clinical demonstrations and ward rounds.

Preliminary programs will be out about May 1. They may be secured, with further information, from Dr. David D. DeWeese, secretary, 1216 S.W. Yamhill Street, Portland 5.

**IMPORTANT** In order that the course may be made more personal and practical, registrations will be limited to 125.

### **ANNUAL MEETING OF PENNSYLVANIA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY**

The annual meeting will be held on April 22, 23 and 24, 1949, at the Penn Harris Hotel, Harrisburg, Pa.

Among the speakers who will present papers at this meeting will be Drs. A. D. Ruedemann, J. R. Lindsay, R. O. Rychener, C. S. Nash, J. G. Linn, Arno Town and G. M. Coates.

In addition to formal presentations, the meeting will include a round table discussion on "Headaches." Among the discussers will be representatives of all major specialties. There will be a study club to discuss "Problems of Cataract," and among the discussers will be Drs. Ruedemann, Rychener and Town.

The incumbent officers are James J. Monahan, president, Shenandoah; Daniel S. Destio, president-elect, Pittsburgh; and Benjamin F. Souders, secretary, Reading.



# Directory of Otolaryngologic Societies \*

## INTERNATIONAL

### FOURTH INTERNATIONAL CONGRESS OF OTOLARYNGOLOGY

President Dr V E Negus, London, England

General Secretaries Dr F C W Capps and Dr W A Mill, 45 Lincoln's Inn Fields, London, W C 2

Place London Time July 18-23, 1949

### SECOND PAN-AMERICAN CONGRESS OF OTO-RHINO-LARYNGOLOGY AND BRONCHESOPHAGOLOGY

President Prof Justo Alonso

Secretary Dr Chevalier L Jackson, 255 S 17th St, Philadelphia 3

Place Montevideo Time January 1950

## NATIONAL

### AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON LARYNGOLOGY, OTOLOGY AND RHINOLOGY

Chairman Henry B Orton, 224 Delavan Ave, Newark, N J

Secretary Dr J Milton Robb, 1553 Woodward Ave, Detroit, Mich

Place Atlantic City, N J Time June 6-10, 1949

### AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Conrad Berens, 35 E 70th St, New York

President-Elect Dr J Mackenzie Brown, Box 584, South Laguna, Calif

Executive Secretary-Treasurer Dr William L Benedict, 100-1st Ave Bldg, Rochester, Minn

### AMERICAN BRONCHO-ESOPHAGOLOGICAL ASSOCIATION

President Dr Paul Holinger, 700 N Michigan Ave, Chicago 11

Secretary Dr Edwin N Broyles, 1100 N Charles St, Baltimore

Place Drake Hotel, Chicago Time April 18-20, 1949

### AMERICAN LARYNGOLOGICAL ASSOCIATION

President Dr Frederick T Hill, 177 Main St, Waterville, Maine

Secretary Dr Louis H Clerf, 1530 Locust St, Philadelphia 2

Place Biltmore Hotel, New York Time May 16-17, 1949

### AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY, INC

President Dr John J Shea, 1018 Madison Ave, Memphis, Tenn

Secretary Dr C Stewart Nash, 708 Medical Arts Bldg, Rochester 7, N Y

Place Drake Hotel, Chicago Time April 18-20, 1949

## SECTIONS

Eastern—Chairman Dr Harold G Tobey, 403 Commonwealth Ave, Boston

Southern—Chairman Dr Watt W Eagle, Duke University, Durham, N C

Middle—Chairman Dr Dean M Lierle, University Hospital, Iowa City

Western—Chairman Dr Leland G Hunnicutt, 98 N Madison Ave, Pasadena Calif

### AMERICAN OTOLOGICAL SOCIETY

President Dr Marvin F Jones, 121 E 60th St, New York

Secretary Dr Gordon D Hoople, Medical Arts Bldg, Syracuse 3, N Y

Place Biltmore Hotel, New York Time May 18-19, 1949

### AMERICAN OTORHINOLOGIC SOCIETY FOR THE ADVANCEMENT OF PLASTIC AND RECONSTRUCTIVE SURGERY, INC

President Dr Samuel F Kelley, 47 E 61st St, New York 21

Secretary Dr Norman N Smith, 291 Whitney Ave, New Haven 11, Conn

### AMERICAN SOCIETY OF OPHTHALMOLOGIC AND OTOLARYNGOLOGIC ALLERGY

President Dr Rea E Ashley, 384 Post St, San Francisco

Secretary-Treasurer Dr Joseph Hampsey, 806 May Bldg, Pittsburgh 22

\* Secretaries of societies are requested to furnish the information necessary to keep this list up to date

## THE MICROTIC EAR

EDGAR M. HOLMES, M.D.  
BOSTON

THE MICROTIC ear has always been and stands to remain a condition which taxes the ingenuity of the surgeon and the morale and personality of the unfortunate possessor. Fortunately, it does not occur more frequently than once in 20,000 births, but this is frequent enough so that the physician sees a sufficient number of cases to appreciate the problems involved and to evaluate the end results of attempted cosmetic and functional improvement.

There are several excellent accounts of the embryonal development of the ear and its relationship to the congenital deformities that are encountered. I would suggest that the works of embryologists such as L. B. Arey<sup>1</sup> and J. Ernest Frazer<sup>2</sup> be studied for the detailed development of the ear and that the papers by J. S. Fraser,<sup>3</sup> J. C. Beck,<sup>4</sup> and L. Richards<sup>5</sup> be consulted for a correlation between the anatomic and clinical findings that may present themselves.

I shall abstract the literature to a brief outline and then discuss the clinical problems as they have presented themselves in various types and degrees of microtia and meatal atresia.

The development of the internal ear is separate from that of the middle and external ears. Its epithelium is derived from the ectoderm.

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From the Plastic Clinic of the Massachusetts Eye and Ear Infirmary.

Presented as a Candidate's Thesis for membership in the American Laryngological, Rhinological and Otological Society, 1946.

1 Arey, L. B. *Developmental Anatomy*, ed 2, Philadelphia, W. B. Saunders Company, 1930, p. 457.

2 Frazer, J. E. The Early Development of the Eustachian Tube and the Nasopharynx, *Brit. M. J.* **2** 1148, 1910, The Second Visceral Arch and Groove in the Tubo-Tympanic Region, *J. Anat. & Physiol.* **48** 391, 1913-1914, The Early Formations of the Middle Ear and Eustachian Tube, *ibid.* **57** 18, 1922.

3 Fraser, J. S. Maldevelopment of Auricle and External Acoustic Meatus and Middle Ear, *Arch. Otolaryng.* **13** 26 (Jan.) 1931.

4 Beck, J. C. The Anatomy, Psychology, Diagnosis and Treatment of Congenital Malformation and Absence of the Ear, *Laryngoscope* **35** 813 (Nov.) 1925.

5 Richards, L. Congenital Atresia of the External Auditory Meatus, *Ann. Otol., Rhin. & Laryng.* **42** 692 (Sept.) 1933.

and is first noticed in the 2 mm embryo as two thickened plates lying on the surface of the head just dorsal to the second branchial cleft. These plates later invaginate to form hollow vesicles and in turn differentiate into the semicircular canals and vestibular apparatus. In the 20 mm embryo, the semicircular canals are present and the cochlear duct has begun to coil like a shell.

The middle and external ears develop slightly later than the inner ear. The middle ear cavity arises from the first pair of pharyngeal pouches and occurs in embryos of 3 mm. The pouches are of endoderm, they grow rapidly and are in temporary contact with the ectoderm. Near the end of the second month, the pouches constrict to form the auditory tube opening into the nasopharynx. The blind end of this pouch enlarges into the tympanic cavity, which is surrounded by loose connective tissue in which the ossicles are developed. Even in adulthood, the ossicles, muscles and chorda tympani nerve retain a covering of mucous epithelium continuous with that lining the tympanic cavity. It is not until the close of the fetal life that the mastoid cells begin to evaginate.

From the condensed mesenchyma of the first and second branchial arches develop the ossicles. The malleus and incus are developed from the dorsal end of the first arch. The inner end of the mandibular cartilage known as Meckel's cartilage forms the malleus and incus and separates from the mandible when ossification begins. The remainder of the cartilage forms the anterior ligament of the malleus.

The stapes is believed to arise from the second branchial arch, which contains a cartilaginous bar known as Reichert's cartilage. It is the inner portion of this bar which becomes the stapes.

The tensor tympani muscle and the fifth nerve, which supplies it, are derived from the first branchial arch. The stapedius muscle and the seventh nerve, which supplies it, come from the second arch. This known relationship substantiates the theory that the ossicles undoubtedly arise from these two separate arches.

The external ear is developed from the ectodermal groove and represents the groove itself, which in time comes in contact with the endoderm of the first pharyngeal pouch. Later this contact is lost and the groove deepens centrally to form a funnel-shaped canal, which is the outer portion of the meatus. From the inner ectodermal surface, a plate grows back and reaches the tympanic cavity. During the seventh month this plate splits and forms the inner portion of the external meatus.

The drum is formed by a thinning out of the tissues where the inner wall of the external auditory meatus contacts the tympanic cavity. Thus, the drum is covered externally with ectodermal epithelium and internally by endoderm.

The auricle arises from the outer lateral part of the first pharyngeal or visceral cleft. Six elevations appear, three on the mandibular arch and three on the hyoid arch. These later fuse to form the adult auricle. The tragus arises from one tubercle of the mandible, the helix from the other two. The antihelix is derived from two of the hyoid tubercles and the antitragus from the remaining one. The lobule corresponds to the lower end of the auricular fold.

With this brief description of the embryology, it is readily understood how the inner ear consisting of the cochlear and vestibular apparatus could be normally developed, and the middle ear, ossicles, external canal and the auricle might be malformed.

This identical condition is frequently encountered, though one sees all degrees of maldevelopment, from the slightly deformed auricle without other defects to the completely absent auricle with all the intervening abnormalities possible.

#### TYPES OF DEFORMITIES

Every day one may see mildly deformed ears if one compares those encountered with the anatomically perfect ear seen in textbooks on anatomy. I do not consider an ear deformed unless there is a gross abnormality which attracts the attention of the untrained eye. The mildest of these is probably the ear which is small over all. Next one could list the ear in which the upper part of the auricle or helix is small and deformed (fig 1). Another malformation similar to this is found in the ear in which the cartilage of the upper end of the auricle is formed but is bound down to the contour of the head (fig 2). In this type of case there is no postaural skin in the upper half of the ear. Further deformity is encountered in which there is little if any development of the upper half of the ear though the concha and lobule are well formed (fig 4). In these instances the meatus is usually well developed. It is usually not until the auricle fails to form that the meatus becomes atretic. With this lack in development, the auricle is usually composed of a folded mass of cartilage covered by skin though the lobule may be fairly well formed (fig 6). The meatus, however, is either filled with fibrous tissue or, as in the majority of cases, is found to be completely nonexistent and to be replaced by solid bone.

When the meatus is patent, at least when the drum can be seen, the hearing is usually within normal limits. If the canal is nearly stenosed the hearing is prone to be decreased, undoubtedly due to a malformation of the drum or ossicles.

With a microtic ear and an absent canal is associated asymmetry of the face (fig 6). This is present in a large proportion of the cases

recorded and in this series was seen in about one half of them. This asymmetry probably goes back to the embryologic period in development that created the other deformities present.

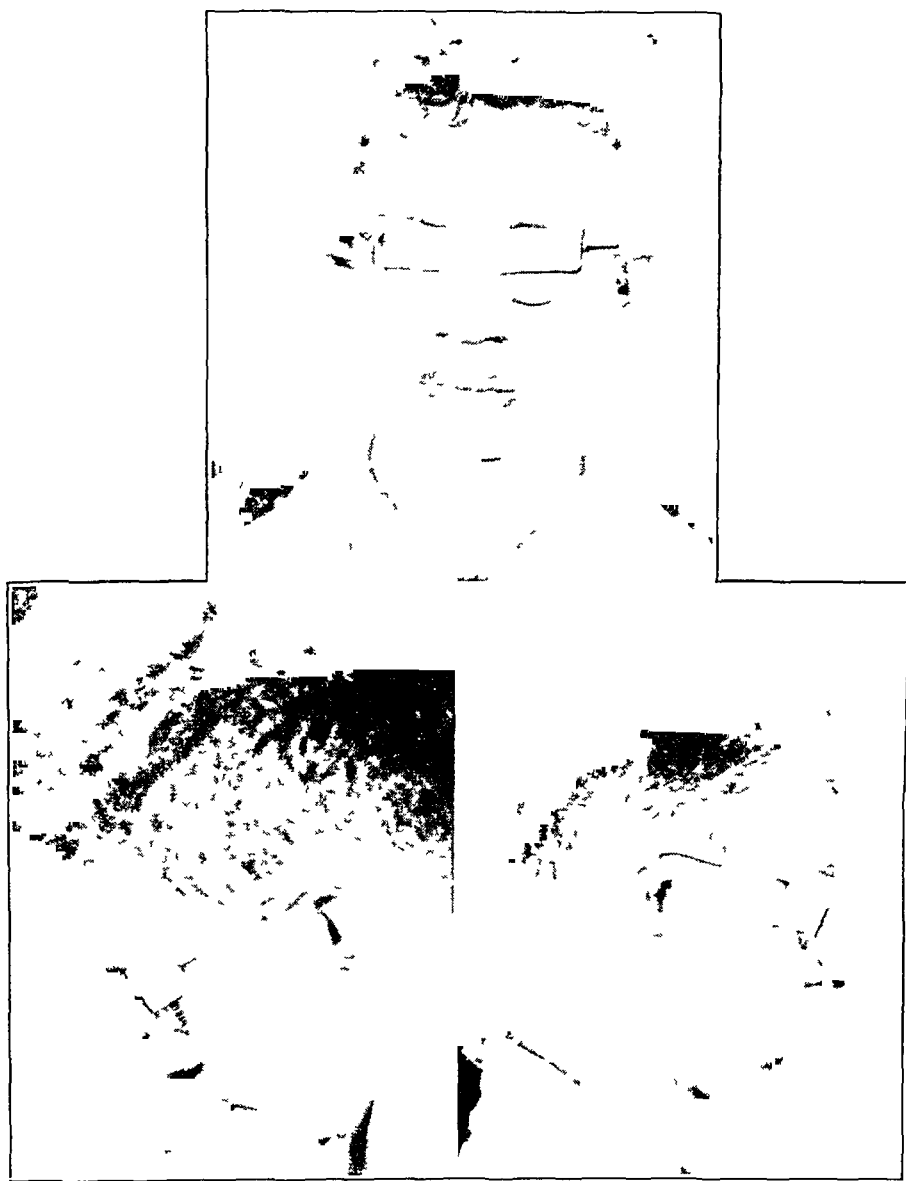


Fig 1—This boy has a mild bilateral microtia. The right ear protrudes from the head slightly, and is slightly cup shaped. The left ear has a fold over the rim of the concha which makes a shelf partly occluding the concha. The helix is smaller than normal. The external auditory meatuses are normal.

Another deformity that is less frequent in its occurrence is the maldevelopment of the ramus of the jaw. It is thought to be due to arrested ossification of the articular cartilage and fits in with the embryologic development of the mandible and ear. When present, there is

marked asymmetry of the jaw with distortion of the face Kazanjian<sup>6</sup> reviewed the literature and presented 5 cases In 1 of these cases he performed a surgical restoration of the missing part by inserting a tibial

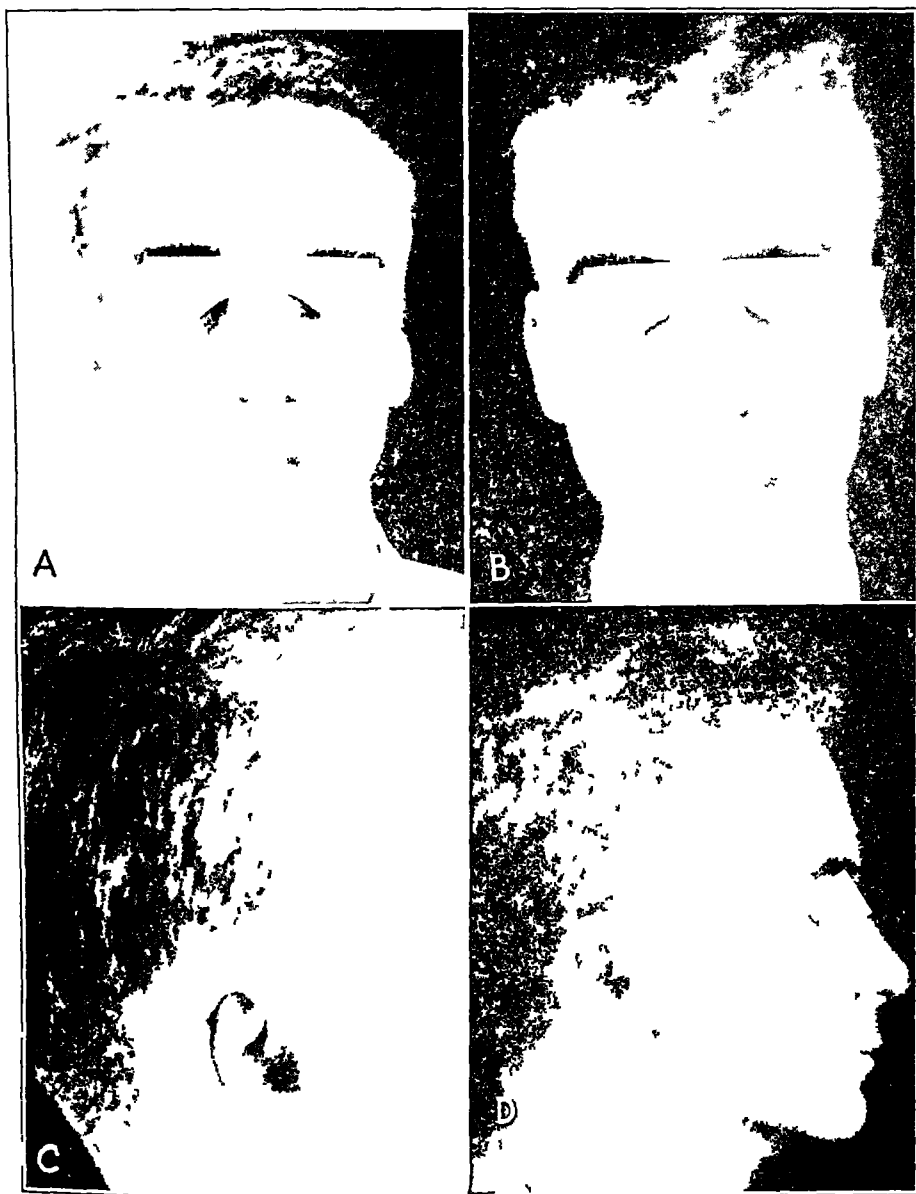


Fig 2—A, in this case, the cartilaginous auricle is well developed, but the upper portion of each ear is bound down to the head. There is no postaural skin in that area. The external auditory meatuses are normal.

B, the postoperative view shows that the helix has been brought away from the head, and there is practically no visible scarring. A flap taken from the postaural skin was utilized to correct the defect.

C, preoperative view of ear. In this lateral view without perspective, it is difficult to see the abnormality.

D, the foregoing statement nearly holds true here except that on comparison with figure C, one may observe that the helix is broader and away from the head.

6 Kazanjian V H. Congenital Absence of the Ramus of the Mandible, *J Bone & Joint Surg* 21 761 772 (July) 1939

transplant to take the place of the absent ramus. When this was completely united, a false joint was made by inserting a fascia lata transplant. After this procedure the patient had good occlusion and use of his mandible.

All degrees of stenoses are encountered. Cases are seen in which the external auditory meatus is narrowed slightly and the drum may be seen. There are others in which it is narrowed to a point where it is impossible to see through it to the depth at which a tympanum is usually found. Beyond this is encountered the completely stenosed canal,

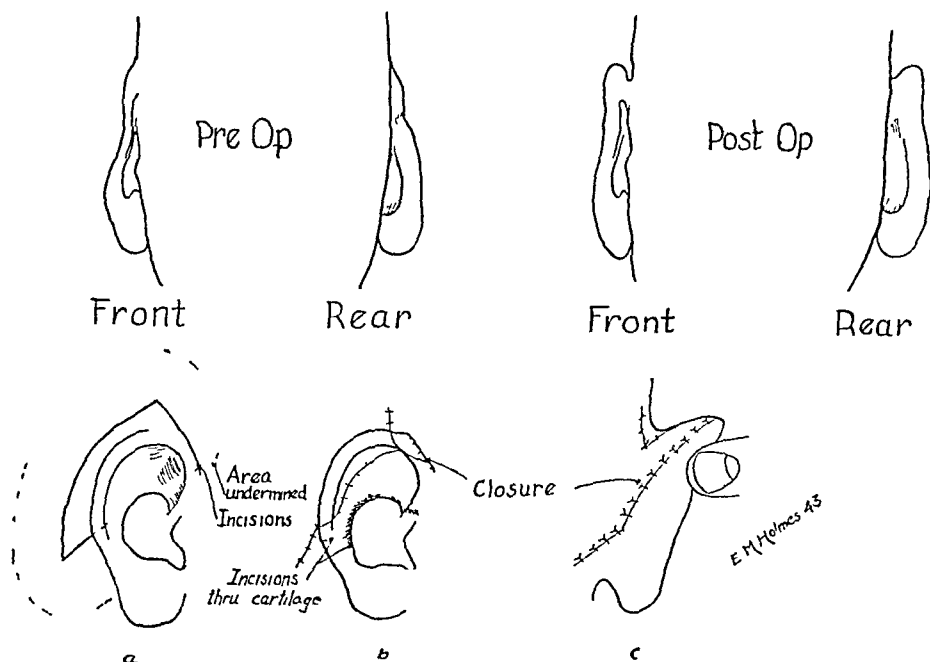


Fig 3—This diagram depicts the steps taken in correcting the defect shown in figure 2A. In *a*, the skin incisions and the area undermined are indicated. In *b*, the cartilaginous incisions are indicated by the dash lines. The skin closures are indicated here as well as in *c*.

which may consist of soft tissue but usually is composed of bone. In the former cases when the drum can be seen there is rarely any loss of hearing, but when the degree of narrowness approaches closure hearing may be reduced. In 1 such case the hearing was grossly diminished, undoubtedly due to a malformation of the drum and ossicles (fig 8B). In the completely stenosed canals one would expect hearing by conduction to be reduced. Tests in these cases proved that hearing was reduced by 50 to 60 decibels. If the normal ear is masked, one may expect a further reduction of 10 to 15 decibels (fig 8A, B, C, D and E).

#### SELECTION OF CASES FOR OPERATION

In choosing a malformed ear for operation there are many factors to be considered. First and foremost, is the operation justified in view of

the goal that may be anticipated? When the external ear alone is concerned and the patient has a patent external auditory meatus and normal hearing, one is guided entirely by the cosmetic and psychologic aspects of the case

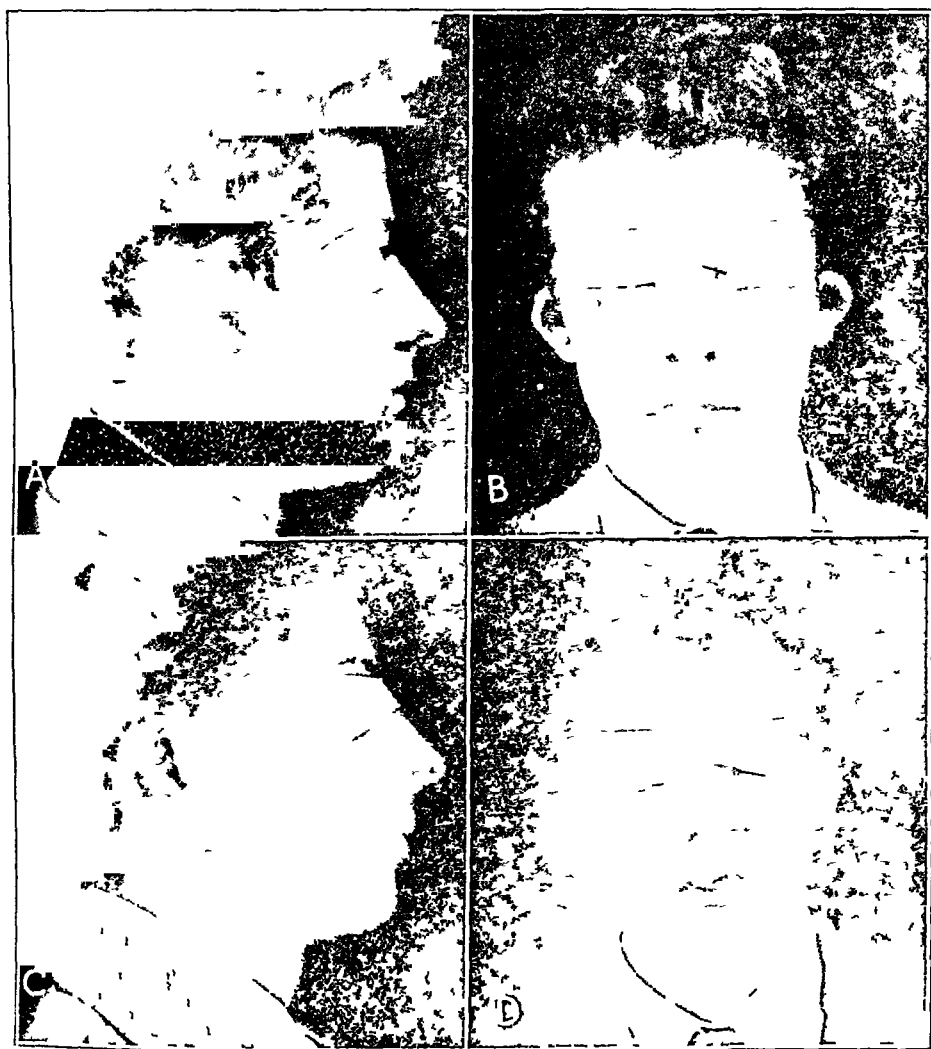


Fig 4—This patient has bilaterally deformed ears. The canals and hearing were normal. *A* and *B* present the deformity. The helix was very short and to correct it the anterior crus of the helix was freed by an incision anteriorly and posteriorly to it. It was then elevated and sutured in its new position. The postaural cartilage was then exposed, and all of the spring and a considerable part of the cartilage removed to permit the ear to form its new bed. *C* and *D* show the finished ear.

Of course, it is probably this psychologic aspect that brings all patients with deformities to see the physician in the hope that sufficient improvement may be made so that the defect will be less noticeable. There are certain persons who are anxious to attempt any degree of correction with the faint hope that their burden may be lightened. If it is



not the person with the deformity, it may be the parents who feel the responsibility for their child's defect and who insist that an attempt at improvement be made. In these cases one may be justified in considering surgical measures even though doubtful as to the ultimate outcome.

The majority of persons with a malformed ear have a mass of tissue which can be adjusted locally to simulate a normal lobule. However, a girl can readily cover the ear and I believe that is all that is indicated.

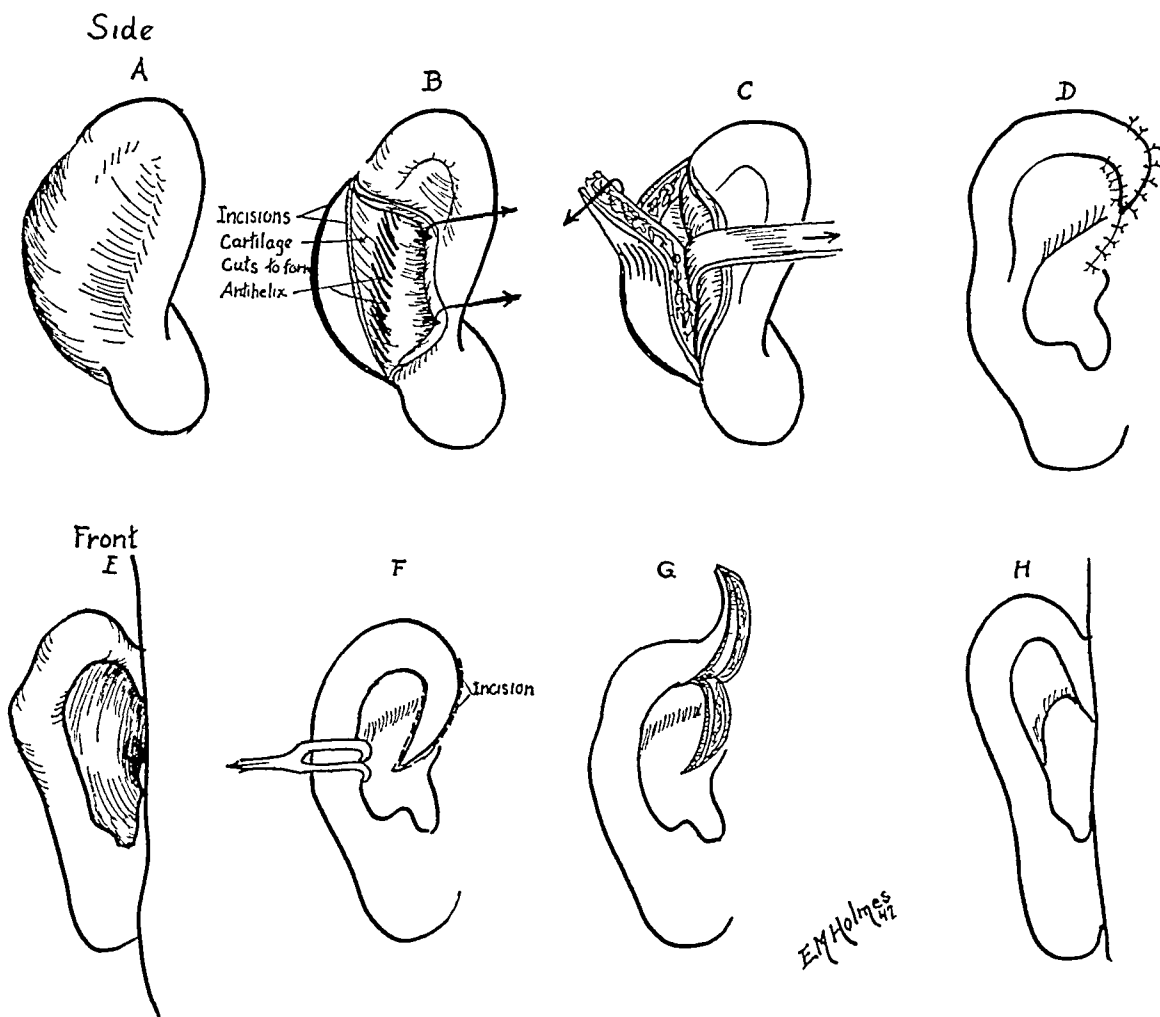


Fig 5—A, ear as it appeared in side view. The concha is not visible.

B, one postaural incision over the conchal cartilage, the other paralleling the postaural fold. The perichondrium is elevated over the entire postaural cartilage and incisions are made through the cartilage to break the spring where the antihelix is to form.

C, an ellipse of postaural skin and subcutaneous tissue is removed down to the periosteum and anteriorly to the auditory meatus. This permits the conchal cartilage to fall back considerably.

D, the finished ear, lateral view. The crus of the helix has been elevated to a new position, thus enlarging the helix. The postaural skin is saved between the anterior incision shown in F and the postaural incision in B.

E, front view, notice marked cupping. F, helix held back to expose concha and show incision to free crus of helix. G, crus of helix elevated. H, finished ear, anterior view.

in the majority of such cases. For, regardless of the perfection of one's technic or the ultimate cosmetic improvement, the reconstructed ear at best is not perfect and can always be noted at a glance, so that the girl would never dress her hair in such a manner that her ears would be

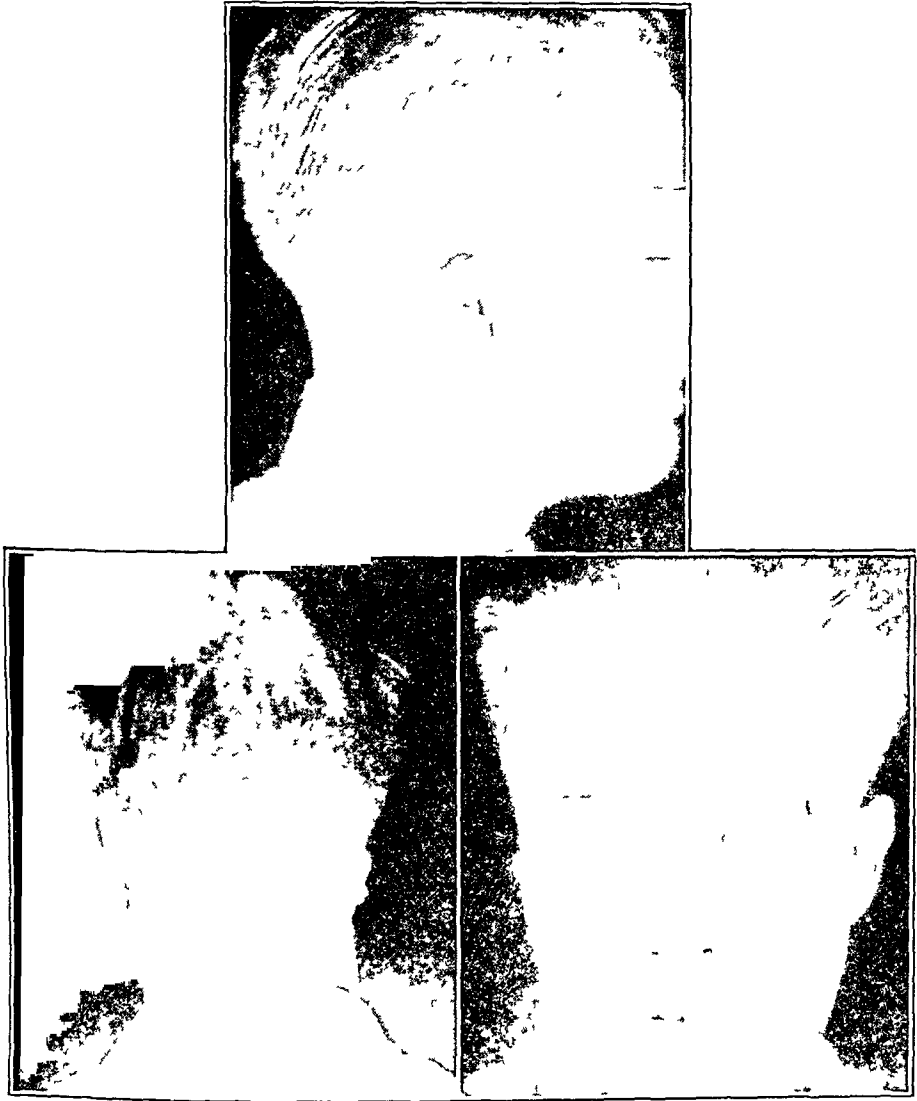


Fig 6—This patient has a unilateral microtia with absence of the external auditory meatus. There was some folded cartilage beneath the presenting auricle. There is flattening of the right side of the face due to asymmetry of growth of the underlying skeleton as well as the superficial skin. The right nostril is smaller than the left and there is a distinct asymmetry of the mouth.

exposed. Other reasons why this procedure should not be advised for a girl are the multiple operations and further scarring in the neck or other localities from which skin may be obtained. Therefore this operation should be performed on a girl only when she insists on it and when she appreciates all the factors involved.

When a boy is encountered with a similar condition, an entirely different attitude must be taken because he is unable to cover his deformity with a normal camouflage. It is, therefore, advisable in the majority of cases to attempt to improve the appearance of the microtic ear. Just

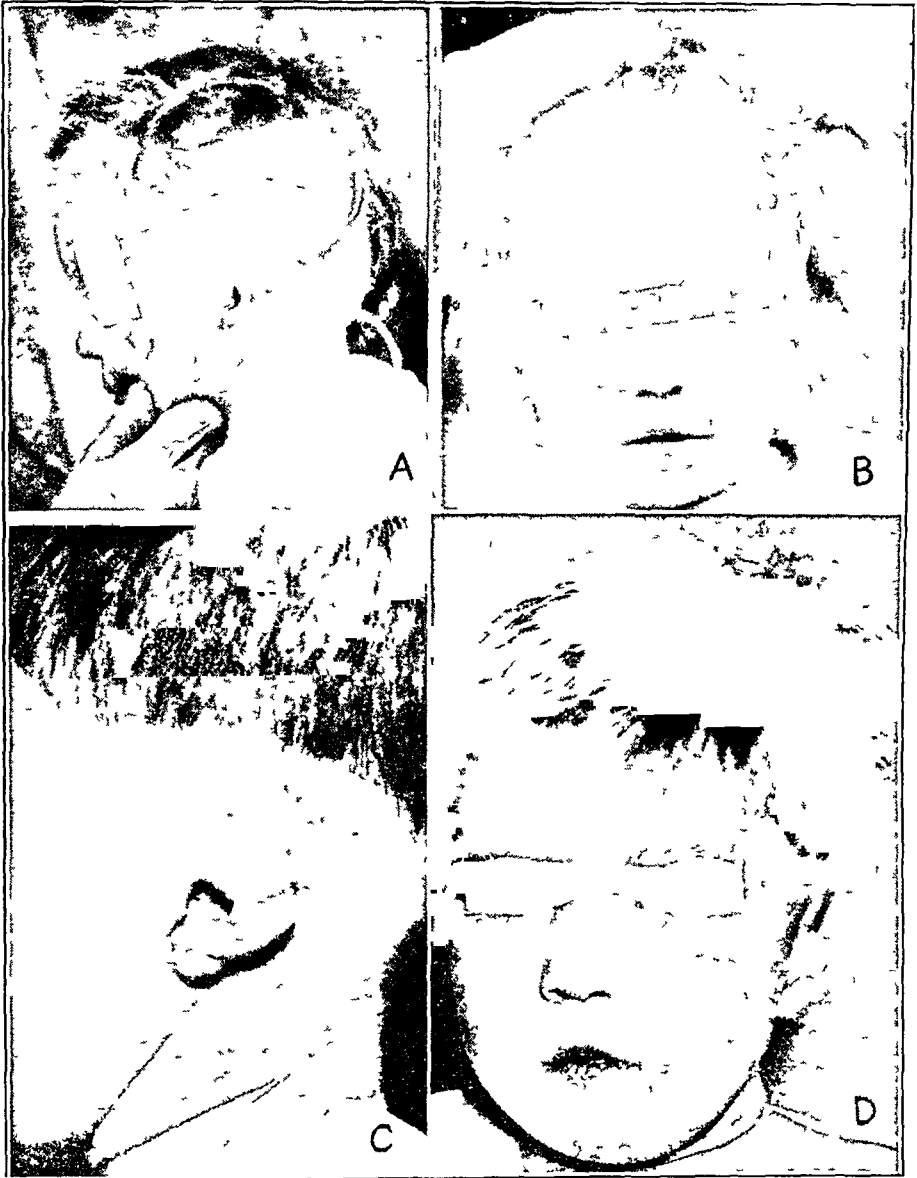


Fig 7—This boy has a nearly complete microtia of the left ear and a marked facial weakness of that side. He has difficulty in closing the left eye. His jaw is nearly symmetric. In *A*, observe the nob of cartilage separated from the remaining concha and double lobule.

*C* and *D*, the lobule has been united and its upper end joined with the skin of the side of the head. The nob of cartilage has been exposed and dissected out. There are incisions near the hair line. It was then cut into sheets and reinserted beneath the skin with additional cartilage taken from the rib. A rope has been made beneath the collar line.

what technic should be used depends on the amount of cartilage and skin present in the deformed ear. This will be discussed later when I consider the types of operations employed.

When the malformed auricle has added to it abnormalities of the external auditory meatus, the problem becomes more complex, as it must be decided whether an attempt should be made to create a new

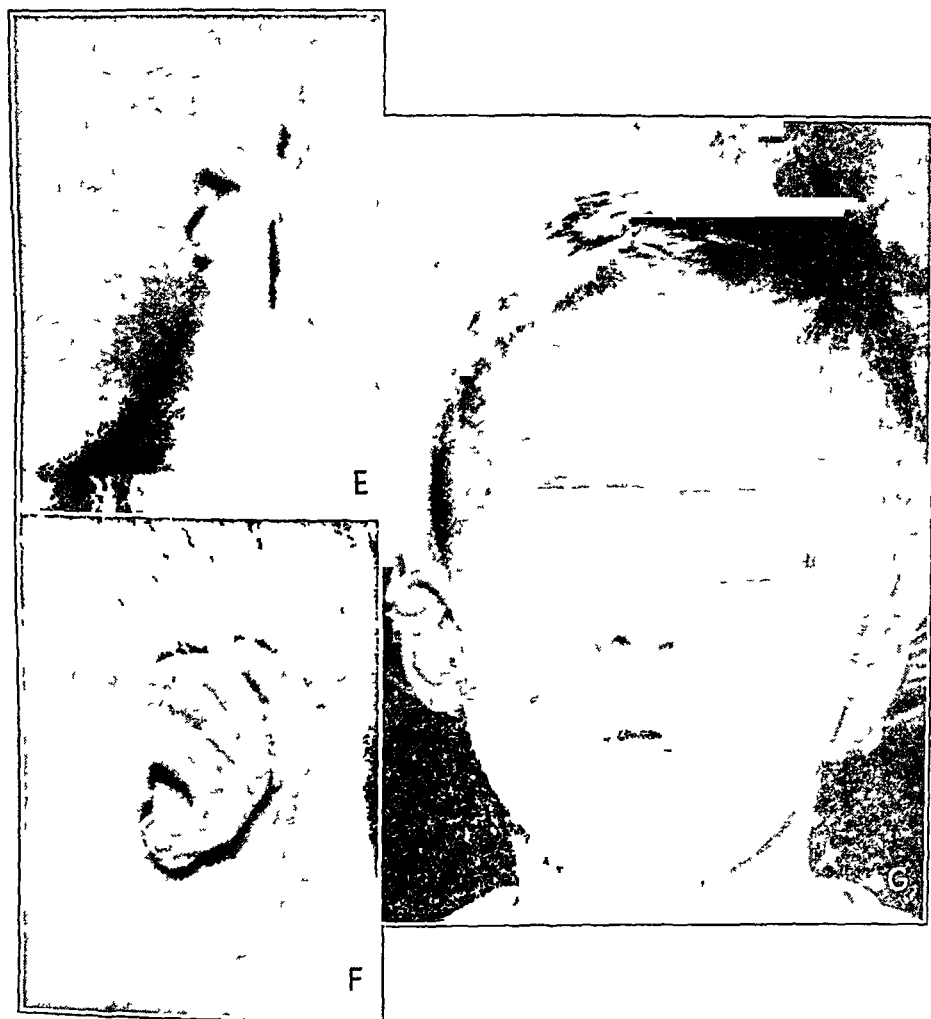


Fig 7—E, the rope has been swung up to a point where at the next operation the remainder can be placed entirely around the auricle to form the helix.  
F and G, the completed ear. Behind the auricle is visible a flap taken from skin lower down.

canal. If the middle ear, semicircular canals, cochlea and ossicles can be seen with the roentgen rays and if a hearing test shows normal bone conduction, one would assume that if an air channel could be brought down to the middle ear structures some improvement in hearing could be obtained. Such, unfortunately, is not the case, as has been proved in these cases. The reason for a lack of improvement is appreciated when

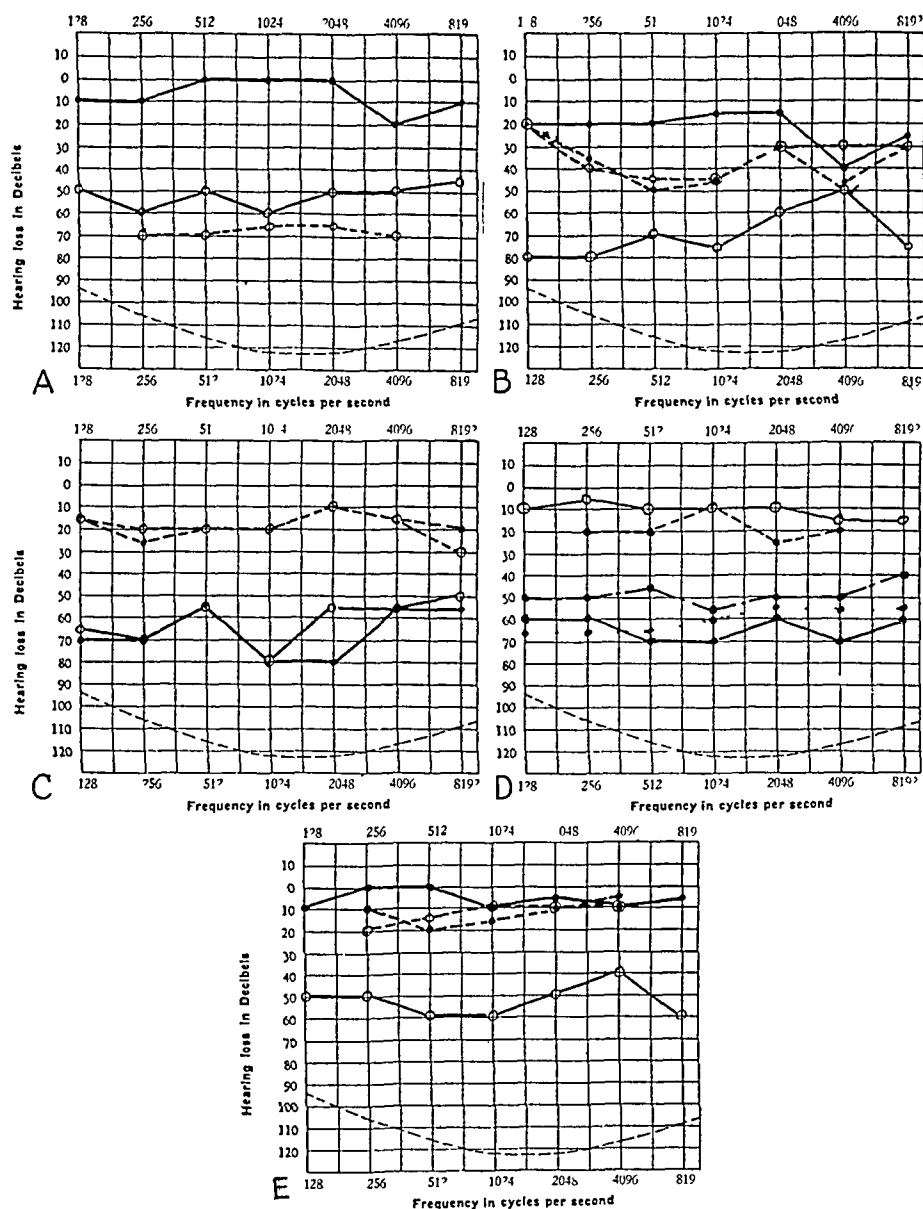


Fig 8—A, an audiogram of a patient without any bony auditory meatus on the left side. The roentgenograms of the cochlea and mastoid are normal. There is no bony canal. The Weber test was lateralized to the left. The hearing in the right ear is essentially normal except for a high and low tone loss. The left ear presents a 50 to 60 decibel loss in hearing. By masking the right ear with a noise apparatus, the hearing level is reduced to nearly 70 decibels. This further loss was noted in all patients so tested. The curve with the black circles indicates hearing in the right ear by bone conduction, the curve with the white circles, in the left ear, the white dot and dash line indicates masked hearing.

B, there is microtia on the left but the patient has a small canal about  $\frac{1}{8}$  inch long (0.3 cm) in diameter extending down to the depth consistent with a normal meatus. The drum could not be seen. The right ear appeared normal. The hearing in the right ear is decreased materially, and in the left is decreased a little more than in most patients with a complete atresia of the meatus. The bone conduction was likewise lower than it is usually observed in these cases. The curve with the black circles indicates hearing in the right ear by air conduction, the curve with the white circles, hearing in the left ear. The dash lines indicate hearing by bone conduction.

it is realized that one finds congenital deformities in the drum and ossicles. Usually a drum is not present, the lining of the middle ear assuming the position of the drum, and solid bone is present to this point. Furthermore, the ossicles are found to be malformed, and fre-

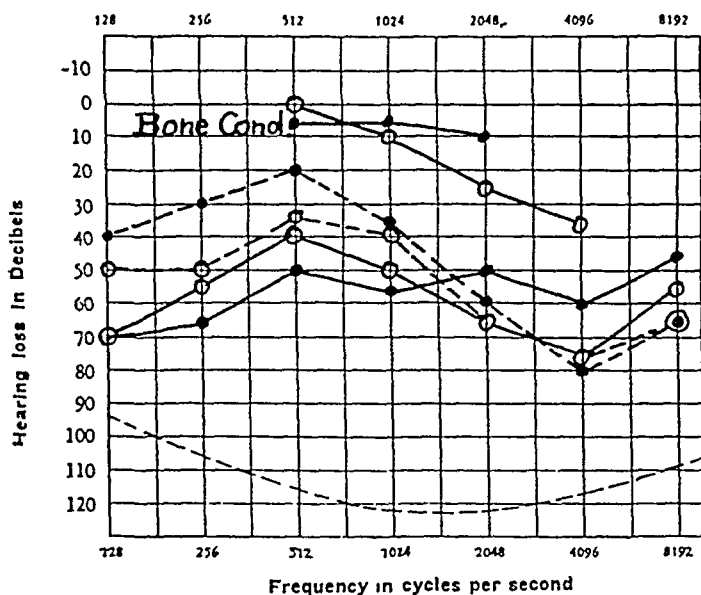


Fig 9—Preoperative and postoperative audiogram of a 12 year boy on whom the author operated. The solid line indicates preoperative hearing and the dash line hearing one month after operation.

quently there is ankylosis between them or they are completely fused. The degree of loss of hearing is about the same as that found in the chronically discharging ear, which is a loss of 50 to 60 decibels.

In the literature the authors showed a striking unanimity of opinion in stating that little, if any, improvement in hearing is to be expected

C, this case presented a bilateral microtia with stenosed meatuses accompanied by absence of malar bones and marked agnathism. The patient's hearing was well below the useful range. The bone conduction was good. His speech was difficult to understand. The symbols have the same meaning as in part B.

D, the patient has microtia of the right ear with a completely stenosed meatus. The left ear appeared normal, and hearing was only slightly decreased. Preoperatively, the hearing in the right ear is indicated by a solid line. Following the creation of a canal down to the antrum, the resulting hearing is shown by the solid line with dots at the top. It should be observed that there was 10 decibel hearing above the preoperative level in all tones. After the operation the hearing improved slightly more, but four years postoperatively when the cavity was clean and the skin graft was still covering the antrum, the hearing was reduced essentially to the preoperative level. There was no practical improvement. This person with good hearing in one ear had his stenosed ear operated on at the insistence of his family. The curves with the black dots indicate hearing in the right ear, the curve with the white circles indicates hearing in the left ear. The continuous line indicates hearing preoperatively, the dash and dot line, one month postoperatively, and the dotted line, four months postoperatively.

E, this patient had microtia of the left ear with no bony canal. The hearing in the right ear was within normal limits and the bone conduction curve was normal for both ears. This relation of bone conduction to a microtic ear is the general rule. The symbols have the same meaning as in part B.

from creating an air channel to the middle ear. This was substantiated in the 2 cases in which I attempted to obtain improvement by such a procedure.

If a person has one normal ear and has had no hearing in the other ear, he does not miss this lost function and for most practical purposes

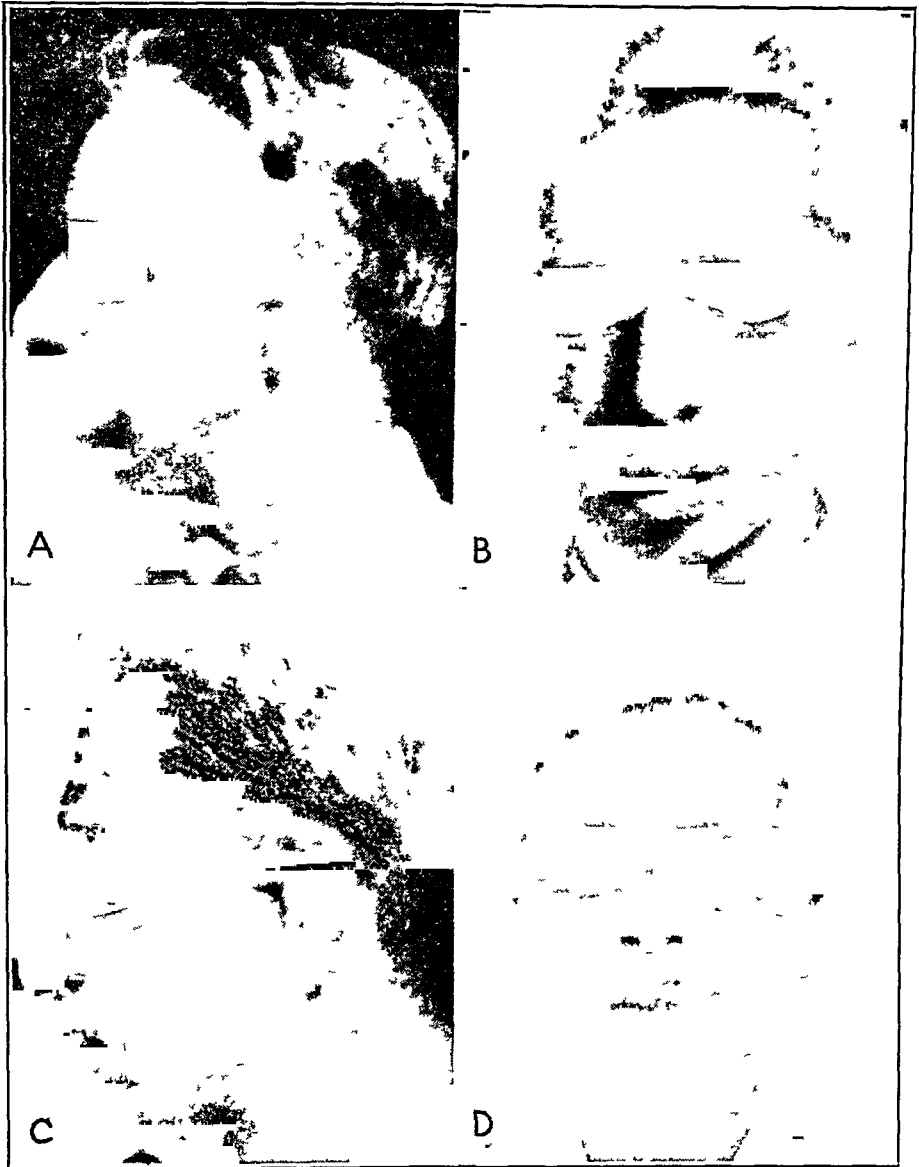


Fig 10—*A* and *B*, this man presented bilateral microtia, absent meatuses, absent malar bones and an agnathic jaw  
*C* and *D* illustrate the finished reconstruction

his one good ear is sufficient. Rarely would such a patient seek improvement of the bad ear.

In bilateral stenosis with hearing below practical levels, the picture is entirely different. In such a case the hearing is so decreased that the

patient may become a social problem. This pathetic situation arises from inability to hear from birth. Not hearing sufficient sounds to form speech habits, the patient's voice and articulation are usually poor. Schooling, except in special schools, is difficult, and his education is usually limited. In these cases every attempt should be made to assist the patient.

Audiograms in these cases reveal an air conduction loss of from 50 to 60 decibels with a bone conduction that may be normal (fig 7C). This being the case, and since there is little hope of improving the hear-



E and F, the first stage of operation was carried out on both ears at the same time. The illustration shows the auricle folded back and sutured to the skin behind with a skin graft over the denuded area. A rope with an island at its middle has been made below the collar line.

G, the rope has been swung up and attached to the auricle. Between this stage and the final result, cartilage was inserted and shaping performed.

ing by creating an air canal to the middle ear, the logical step is to fit the patient with a bone conduction hearing aid. There were only 2



cases of complete bilateral stenosis in this series. One of these patients did not have the intelligence to cooperate sufficiently to permit a hearing aid to be fitted, while the other one failed to return to the clinic.

Should one of these persons have acute otitis media, a problem would be encountered which would call for special consideration. It is obvious that paracentesis could not be done to obtain external drainage, and the chance of a secondary complication is therefore slightly increased. With the chemotherapeutic drugs now at the physician's disposal, the likelihood of performing a mastoidectomy in these cases is reduced. It is obvious, however, that such patients must be watched closely, and if symptoms indicating complications are noticed or the mastoiditis is not subsiding, mastoidectomy should be done immediately. As indicated by roentgenograms, the majority of microtic ears have normally developed mastoids. Should an operation be called for, the simplest procedure would be to perform a mastoidectomy, exenterating the diseased mastoid. The incision could then be closed, a small catheter being left in the wound for instillation of penicillin. This would require careful supervision, and when the wound was healed there would remain a dead space ready for reinfection. A more logical procedure of completing the operation is to create a canal down to the antrum. This is readily accomplished by excising a large core of tissues to the antrum and covering the raw area thus formed with a split skin graft. This is not only creating an opening to the antrum but forming a diaphragm of skin across the space, thus walling off the middle ear from the newly created canal.

Realizing that there is little hope of improving the hearing by the methods tried in the past, I should like to see a fenestration operation attempted in one of these cases. There would be no skin flap which could be brought down over the fenestration window, but I am confident that a thin Thiersch graft could be substituted with success.

NOTE—Since writing of this article, Pattee<sup>7</sup> suggested and confirmed the logical solution to improving the hearing in these cases. He determined that the lack of improvement in hearing after the creation of an airway to the middle ear was due to the fixation of the stapes by the malformed and usually ankylosed malleus and incus. The logical step in liberating the fixed stapes was therefore to remove the incus. Skin may then be grafted on the mastoid cavity created to expose the incus. Pattee showed by audiograms that the hearing could be brought up into the useful range. I have already confirmed this procedure in 1 case and have others which I hope to report on later.

The patient on whom I operated was a 12 year old boy without external auditory meatuses, who had fairly well developed auricles.

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<sup>7</sup> Pattee, G. L. An Operation to Improve Hearing in Cases of Congenital Atresia of External Auditory Meatus, *Arch Otolaryng* 45:568-580 (May) 1947.

Speech was fair, articulation being good. His preoperative audiogram (fig 9) shows a hearing loss below 50 decibels in both ears except for the 512 frequency in the left ear, which is 40 decibels. His bone conduction was within normal range except in the high tones. At operation, a simple mastoidectomy was done exposing the antrum, the semicircular canals were skeletonized and the antrum enlarged only sufficiently to remove the incus. On both sides the incus was fairly well developed and attached to it was a small piece of the malleus. Examination of the specimen under magnification showed there was no evidence of fracture of the malleus. It was malformed, with a little body and no long process. This would indicate that the incus was not fixed by the malleus except where the latter may have been immobilized by fibrous bands. Following the operation, the cavity was immediately lined with a split skin graft. The audiometric reading taken one month postoperatively showed decided improvement in the right ear and only moderate improvement in the low tones in the left ear. For the high tones, 2448 and 8192 frequencies, there was no improvement in the left ear and a loss in the right ear. It will be interesting to see this patient in six months and one year and to compare the hearing with that one month after operation.

Subjectively, he hears much better and his conversational distance has improved from 1 foot (30.48 cm) to 8 feet (243.48 cm). His family said that his speech had improved.

This procedure is definitely a step in the right direction in these cases and gives one an opportunity to improve the hearing in patients who could not have been helped before.

#### FACIAL NERVE

If an operation for the improvement of hearing is considered or mastoidectomy must be done in these cases, the operator must be mindful always of the fact that the facial nerve may be malplaced. Such is usually the case, and not only is the nerve in an unknown position, but it may be in solid bone so that there are no landmarks other than the horizontal canal showing the operator that he is approaching it. The nerve may also be smaller than normal, which may account for the facial weaknesses seen in some of these patients. When uncovered, it could be mistaken for the annular ligament, as was first the case in one of my patients on whom operation was performed.

#### PROSTHESES

Appreciating that it is most difficult to obtain a presentable ear through surgical procedures, should one not turn directly to the creation of a prosthesis which will simulate the other normal structures and one

which the patient may wear? Not until the past two or three years have many new materials been at the prosthetic molder's disposal, and it has been extremely difficult to obtain a prosthesis which can alleviate a deformity instead of making it more conspicuous. I shall not deal with the various procedures for making prostheses other than to mention that the prostheses have been made of gelatin formulas, dental composition, acrylic substances, rubber and other materials. Some of these are painted with oil paints to simulate the color of skin. Others have the pigments within their structure. The prostheses which I personally have found to be most satisfactory in color, weight and appearance have been made of "Vultex" which is a prevulcanized latex with the color incorporated. The trouble with these prostheses is that after they have been worn for some time the oils of the skin attack them and they begin to go to pieces. With all of these prostheses, there is the difficulty of attaching the appliances without causing irritation to the underlying skin. In many cases the condition is so unbearable that the patient is unable to wear a prosthesis for any length of time. Another drawback to a perfect structural prosthesis with normal color is that the color of normal ears changes from day to day and from temperature to temperature, and it is nearly impossible to find a patient who is capable, though willing, to attempt to color the prosthesis by cosmetics to match the opposite ear. The majority of patients prefer to put on a prosthesis the way they would a hat and forget that the color or its exact position is an important factor. With the stimulus of the war, forward strides have been made in producing prostheses and present reports are most promising. I am anxious to learn whether these new prostheses stand the test of time.

#### TYPES OF OPERATIONS

Each case must be thoroughly investigated and studied before a decision is made as to the type of procedure to be followed. Pictures should be taken of the patient and a plaster cast made of the deformity. Then a careful audiometric study should follow and roentgenograms should be made to determine the degree of bony abnormality and the amount of residual or potential hearing. The patency of the nose, the nasopharynx and particularly of the eustachian tubes should be determined. Of course, to determine the patency of the eustachian tubes one must rely on the patient's subjective sensation on inflation, as auscultation is difficult.

I shall first discuss the practicability of procedures that may be used to reconstruct an auricle and then the operations to form an external auditory meatus which have been found satisfactory in this clinic.

There are several fundamental procedures that may be considered in the reconstruction of an absent ear. The literature dates back to the

sixteenth century, describing a case in which an ear, partially lost, is restored. The reconstruction was formed by utilizing local neck flaps. It was not until 1870 that Szymanowski described the complete reconstruction of an ear. He raised local flaps, folded them on one another and placed grafts on the resulting raw area.

Next are presented the procedures employed by various authors to reconstruct an absent or deformed ear. First, autogenous cartilage was transferred from the patient's rib, later it was taken from other persons, preserved and employed for transplants. Recently ear cartilages from willing donors or even from a cadaver have been used. None of these worked perfectly, so that when the inert metals were developed they were employed as a supporting medium. Flaps were gradually used from more distant parts of the neck, finally reaching the level of the clavicle, where the skin is thinner and of a more suitable type for molding. Of course, flaps have been used from the arms and other parts of the body.

Regardless of the procedure employed, the end results are never those to which one would aspire. In any form of reconstruction it is advisable, when possible, to employ transplants which will continue to maintain the shape given them. Utilization of autogenous cartilage transplants usually meets this requirement for support. When thin, they have a tendency to curl and alter their shape, and this is a severe drawback. Homogenous cartilage from the standpoint of the quantity obtainable and the ease with which it may be obtained and shaped makes it a medium of choice. Its drawback is its tendency to be replaced by fibrous tissue and in time to lose its bulk and spring. This has had a decided influence in discouraging the use of maternal or borrowed whole ear cartilage. Tantalum has the advantage of being inert, readily formed to any desired shape and an easy material to insert in a reconstructed ear. I have used it several times to form the support of a newly formed helix. Its drawbacks are that it is not very flexible, so that if it is bent it stays in the new position, and if there is any pressure of the metal under the overlying skin the metal is prone to work its way through to the surface by a pressure necrosis. This has necessitated the removal of three tantalum coiled wires which were employed to shape the helix. Tantalum in the form of a fine wire framework has been utilized and, theoretically, should work better than stiffer forms.

#### OPERATIVE RECONSTRUCTION OF THE EAR

To reconstruct a microtic ear so that it will be more normal in appearance, the existing tissues must be utilized to the best advantage. Then skin must be borrowed from the adjacent areas or from a distant part. Third, some form of skeleton must be used to support this skin.

*Types of Operations*—One of the deformities that presents the least deviation from normal is that in which the auricle is well developed though the upper pole is bound down to the head (fig 2). The problem of correcting the defect is comparatively simple in that all the cartilage necessary is present and it is in nearly normal position. It is necessary to free the upper pole and obtain skin to cover the defect which is left when the ear is brought away from the head. A simple procedure to effect this goal is to create a flap of postaural skin which may be transferred to cover this postaural defect (fig 2).

When the auricle is freed from its bed it becomes necessary to break the spring along the antihelix so that the auricle will stay in its new position. This is done by incising the cartilage from behind through to the skin on the anterior surface just below the rim of the antihelix. When the central roll of the antihelix is encountered, the straight incision is converted into many small parallel tangential cuts through the cartilage. The skin is then closed as indicated in the diagrams (fig 2C).

I shall now consider the problem of improving an ear in which there are a concha and lobule plus the lower half of the helix, the upper half being short and partially absent. The entire presenting ear is nearly at right angles to the head and cupped (fig 4). The problem here is twofold. First and foremost is the rearrangement of the existing parts to open the auricle and, second, the finding of a procedure which will make the ear lie closer to the head. The procedure that works best in these cases and has proved satisfactory has been one which frees the antitragus as it dips into the concha, elevating it to a new position higher up. This permits the helix to unfold, and the bed from which it comes is approximated. A postaural incision is then made parallel and just below the conchal rim from the dependent part of the ear upward to within three fourths of an inch (1.9 cm) of the top, the latter area being untouched to maintain sufficient blood supply to the newly formed tragal crus. The entire conchal cartilage is then exposed. The tissue between the concha and the mastoid periosteum is removed. This in itself permits the concha to be brought back, in many cases a sufficient distance to take care of a mild lop ear. The conchal cartilage is then shaved off. Small areas of the underlying skin are exposed so that not only will the ear go back farther, but there will be a true fibrous contact between the concha and the periosteum. The area where the antihelix should be is then weakened by many diagonal parallel cuts through the cartilage to the skin. This permits the cartilage to be folded back without creating irregularity on the anterior surface. Similar incisions are made to create the crura antihelica which will form the fossa triangularis. Occasionally it is necessary to remove a crescent of cartilage just beneath the antihelix to permit the remaining auricle to fall back into place. When all the spring is broken, the ear will usually stay in an unfolded position, but to prevent its going back to its former shape before the dressing is applied or during its application, it is advisable to place a through and through mattress suture from the anterior surface through the cartilage and out through the skin again on the other side of the newly formed antihelix or other folds. The skin is protected from the sutures by a small piece of gauze over which the suture rests. Excess postaural skin then may be excised, or if it is needed to bring the upper part of the helix away from the head, it may be swung as a pedicle flap into the desired location.

The next type of ear encountered is one in which there is an external auditory meatus and concha and the rest of the ear is quite malformed. The lobule is folded forward and the rest of the ear is nonexistent (fig 7). The problem in this case is to reconstruct all of the auricle except the concha and lobule. In this par-

ticular condition a satisfactory procedure is to attach the lobule to the skin above so that its lateral surface is flush with the temporal skin (fig 7C and D) At this time cartilage taken from the rib is shaped and inserted beneath the skin which will create the auricle A rope is also started below the collar bone to form the new helix Two or three weeks later, the anterior end of the rope may be transferred to the inferior position of the helix or to any appropriate position where it may later be swung into place A few weeks later, the other end of the rope is severed and brought up to its new position At the same time cartilage is inserted into it At the next operation, the newly created auricle is lifted from its bed and a local skin flap is swung up to cover the posterior surface of the auricle, the remaining exposed area being covered with a full thickness graft from behind the opposite ear (For details, see fig 7I)

The last and most deformed type of microtic ear is composed of a small mass of folded cartilage, a deformed lobule and no concha or external auditory meatus Several technics to correct this defect are described A procedure which works satisfactorily is as follows An incision is first made anteriorly to the mass of cartilage and skin which is present (fig 10A and B) Parallel incisions are made at each end of this incision backward to the posterior margin of the mass The skin containing the cartilage is dissected free, when possible, so that it opens up as a book, and is hinged at the posterior border of the parallel incisions Another incision is now made parallel to the hair line and this flap is sutured to it, thus holding the cartilage and skin back and open The tissue of the denuded area which would correspond to the location of a concha is then excised down to the periosteum over the mastoid In doing this, care must be taken not to enter the temporomandibular joint, which is in this vicinity A Thiersch graft is next taken from the inner aspect of the thigh and applied to the denuded area, being held in place by a stent molded to fit the area At the same stage one can start a rope graft which is to form a new helix and possibly to cover some of the anterior surface of the new ear (fig 10E and F)

The three main places from which this skin may be easily taken are (1) along the margin of the hair line from the ear down, (2) under the collar line by a transverse incision and (3) the region of the clavicle

The first location has the advantage of being near the auricle, where skin is easily transferred without multiple transferences of the rope This has its disadvantages in that the skin toward the lower part of the area from which the graft is taken becomes thick and later may develop hair which is not apparent at the time the rope is formed It has the further disadvantage of creating another scar which is visible and may be unsightly

The second location is ideal in that a long rope may be obtained which can be swung directly to the desired site if the posterior end of the rope is made sufficiently high The skin is usually thin and adapts itself readily to its new position

At the third site, over the clavicle, the skin is thin and ideal, but it is difficult to swing the rope to its new position without multiple steps

The next procedure consists of transferring the far end of the rope to the region of the crux of the helix when possible In this same procedure it is possible and advisable in the majority of cases to insert a thin strip of cartilage in the rope, which will create contour in the new helix It is usually also advisable to add more cartilage between the skin flap and skin graft which were first made (fig 10G)

The next procedure consists of severing the pedicle and transferring the rest of the graft to the new auricle together with such shaping as the blood supply will permit At this step, the auricle is freed from the hair line where it was first sutured

The remaining procedures consist of shaping the tissues at hand and the occasional insertion of more cartilage

## SUMMARY AND CONCLUSIONS

An abstract of the embryologic development of the ear is presented

The congenitally microtic ear occurs about once in 20,000 births and varies from the mildly deformed ear to one which is practically absent and has no external auditory meatus

When a patient has one normal hearing ear, it is not advisable to attempt to create a canal to the middle ear on the abnormal side, as the prospect of improving the hearing to a useful level is not good and the risk of injuring an abnormally placed facial nerve is greater than in a normally developed ear

In a case of bilaterally stenosed canals, an attempt to improve the hearing should be made. The procedure makes an opening through the mastoid to the antrum where the incus is removed

When a girl is encountered who has a microtic ear, it seems prudent to advise her to cover the deformity with her hair, as the visible scarring made necessary by the reconstruction of the auricle offsets any possible improvement of the ear

The various types of cases encountered are presented, together with the surgical procedures to correct them

Regardless of what technic is employed, or what tissues are used, the reconstructed ear cannot take the place of a normally developed ear and will never be inconspicuous

These, then, are in brief the satisfactory procedures for the reconstruction of an auricle. Of course, in no 2 cases can the reconstruction be done in exactly the same manner, as the tissue involved is not the same in size or in elasticity. Certain persons produce more scar tissue than others, while in some keloids form which are difficult to manage

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## FRACTURES OF THE HYOID BONE

Presentation of Two Cases, with a Review of the Literature

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### INCIDENCE

**F**RACTURE of the hyoid bone is a rare condition, however, it is probably not as rare as the number of cases reported in the literature would indicate. Some interest was manifested in regard to this condition around the close of the last century, but reports have been scanty in the recent literature. Two cases of fracture of the hyoid bone were observed in this hospital within a period of one month.

Stimson<sup>1</sup> in 1907 was able to collect 45 cases from the literature. He felt that in 2 of these the fracture was probably due to muscular action alone. In many of the cases the fracture resulted from judicial or suicidal hanging and were accompanied by fractures of the thyroid and cricoid cartilages. Doubt may be entertained in some of the cases, as they occurred before the advent of roentgenology, when diagnostic methods were of necessity crude.

Even when garroting was a popular method of killing among murderers it was reported that fracture of the hyoid bone occurred in only 0.002 per cent of cases of this type of violence.

### ANATOMY

The hyoid bone is an unpaired horseshoe-shaped bone consisting of five segments: the body, two greater and two lesser cornua. The bone is in close relation to the larynx and acts as the main support of the tongue. The greater cornua are attached to the styloid processes of the temporal bones by ligaments. The bone is subcutaneous along most of its course. In spite of this, its flexibility and the flexibility of the surrounding structures afford it great protection.

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1 Stimson, L. A Practical Treatise on Fractures and Dislocations, ed. 6, Philadelphia, Lea & Febiger, 1910.

## CAUSES

There are probably two distinct causes of fracture of the hyoid bone (1) direct trauma of the bone, as in hanging, manual strangulation, a blow directed to the side of the neck and accidents in which the neck is run over, (2) Muscular pull on the bone, whether it is from forcible swallowing or from sudden hyperextension of the neck

The first cause is by far the more common, and on the basis of the cases reported in the literature it probably accounts for 90 per cent of all fractures of the hyoid bone To Ollivier d'Angers must go the credit for first describing a fracture of the hyoid bone due to muscular action alone The first edition of Hamilton's<sup>4</sup> textbook, published in 1860, contains a report of a case of fracture due to muscular action Poinat<sup>5</sup> collected 3 more such cases, bringing the total to 5 Since roentgenology developed, at least 5 more cases in which fracture of this bone was due to muscular action have been reported (table)

The two causes of fracture of the hyoid bone were exemplified in 2 cases studied at this hospital

## REPORT OF CASES

CASE 1—Mr A S, a 32 year old Negro man, entered this hospital in June 1947 because of a progressive feeling of depression He had become confused, and, although oriented in all spheres, he was somewhat retarded mentally He was negativistic and had only superficial insight in regard to his illness The physical examination gave essentially negative results, as did the neurologic examination The results of the routine laboratory tests were within normal limits The diagnosis was schizophrenia, mixed type

About one month after admission, while the patient was in a ward for patients with acute mental disease, awaiting shock treatment, it was noted that a mass had developed in his neck The mass was located anterior to, and slightly above, the thyroid cartilage It was about the size of a hen's egg, was hard, smooth and warm, and had a dull ruddy color (fig 1) It was tender and moved with swallowing The patient's voice was hoarse, and he experienced some pain on speaking and swallowing No evidence of trauma was seen

Anterior posterior and lateral films showing the soft tissues of the neck revealed that the mass was located just below the hyoid bone and in front of the thyroid cartilage Close scrutiny revealed a transverse fracture of the right greater cornu of the hyoid bone about 0.5 cm from the junction of the cornu and the body of the bone (fig 2) There was no displacement of the fragments

The patient was fed by tube, and cold packs were applied to the tumefaction In five days the mass had receded, and the contour of the neck was normal The

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3 Footnote deleted

4 Hamilton, F H A Practical Treatise on Fractures and Dislocations, Philadelphia, Blanchard & Lea, 1860

5 Poinat, cited by Hamilton,<sup>4</sup> ed 8, revised and edited by S Smith, Philadelphia, Lea Bros & Co, 1891

*Reported Cases of Muscular Fracture of the Hyoid Bone*

Case and Body Habitus	Age	Signs and Symptoms	Röntgenologic Observations	Treatment	Course
Olmsted Arch Oto laryng this issue case 1 Asthenic habitus	32	Pain in neck dysphagia, tumefaction of neck	Fracture of right greater cornu near junction with body	Rest in bed rest of voice ice bag to neck, liquid diet	Patient recovered in 1 wk fracture re- mained ununited
Asheer athletic habitus	29	Pain in neck change of voice pain on protruding tongue hoarseness dysphagia bloody sputum	No roentgenogram taken clinically a fracture of the left greater cornu	Conservative no manipulation	Patient recovered
Personab athletic habitus	64	Pain in throat inability to swallow weak voice	Fracture of left wing of hyoid bone	Conservative, no manipulation	Patient recovered
Foebes asthenic and undernourished	42	Sharp pain in neck extreme dysphagia hoarseness a feeling of bone in throat	Fracture of left wing of hyoid bone 0.5 cm from tip, which perforated pharynx	Fragments placed in alignment by means of index finger be- hind tonsillar fossa and hand on neck over fracture	Patient recovered in 2 wk
Kleinberg athletic habitus	21	Sore throat painful articula- tion bloody sputum dyspha- gia subcutaneous emphysema of neck and chest	Fracture of greater cornu at junction with body	Conservative for 1 week	Patient recovered

patient was returned to his ward, where he began to eat and talk without pain. One month later all signs and symptoms referable to the neck had disappeared. The fracture remained ununited.

It is of special interest that this patient from the time of admission to the hospital was under close supervision of attendants, doctors and nurses day and

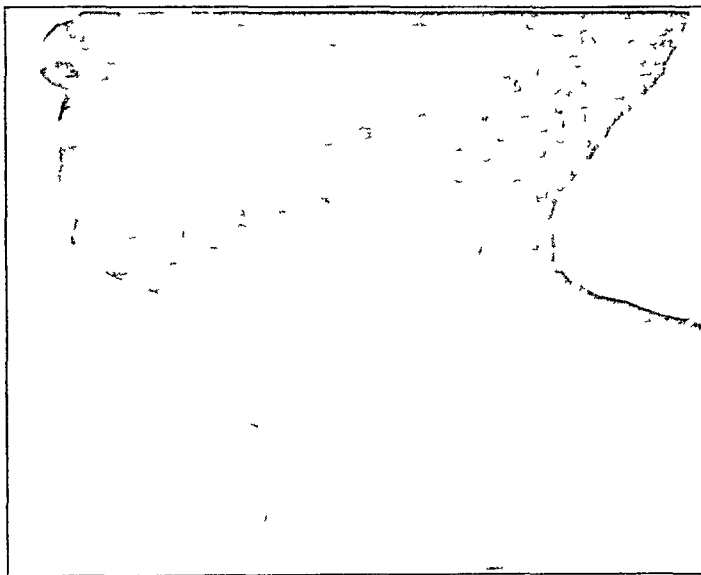


Fig 1 (case 1) —The patient has a tumefaction of the neck just below the fractured hyoid bone in the region of the thyroid cartilage

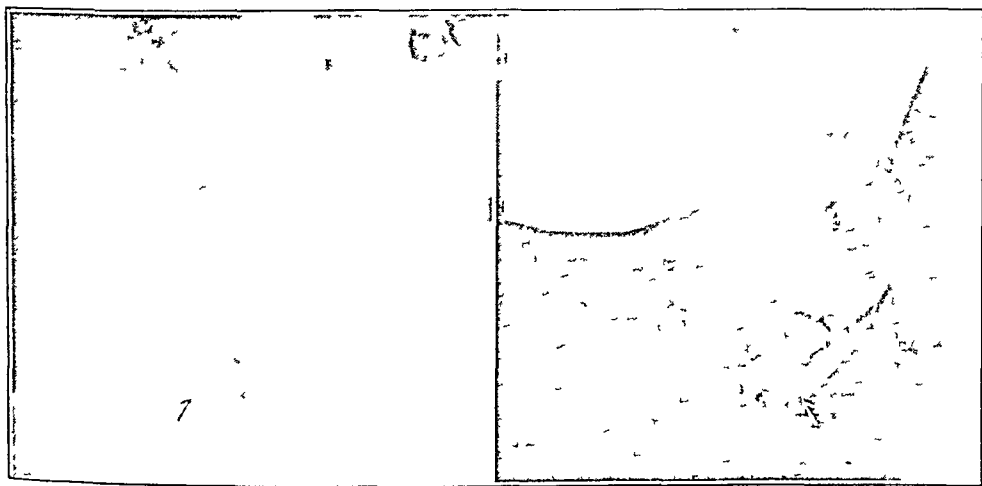


Fig 2 (case 1) —Negative and positive roentgenograms giving a lateral view of the region of the neck. Note the fracture of the hyoid bone (arrow) near its junction with the body of the bone

night. At no time was there any altercation of trauma. The patient denied that any one had struck him or that he had injured himself. It had been noted that at times he was given to manneristic movements of the neck. As far as can be determined, this is an example of fracture of the hyoid bone due to muscular action alone.

CASE 2—Mr R K, a 34 year old white man, was admitted to this hospital in August 1947. He had been responding to auditory hallucinations, and three days prior to admission had attempted suicide by hanging. He had dropped a distance of about 6 feet (about 2 meters) with the rope around his neck. He lost consciousness but was cut down by friends before he strangled. On regaining consciousness a few minutes later, he found that his voice had become hoarse and of a lower pitch. Articulation and swallowing were painful.

On admission to the hospital he appeared essentially normal except for abraded and ecchymotic areas around the throat. There was distinct asymmetry of the neck, the left side being flattened somewhat in its lateral diameter. Point tenderness was elicited over the left greater cornu of the hyoid bone. Examination of the mouth, throat, and larynx failed to disclose any pathologic condition.

Left lateral roentgenograms of the neck showed a transverse fracture in the midportion of the left greater cornu of the hyoid bone with angulation of the posterior fragment (fig 3).



Fig 3 (case 2) —Negative and positive roentgenograms giving lateral view of the region of the neck. Note the fracture of the hyoid bone (arrow) with angulation of the posterior fragment.

The patient received conservative treatment, and no attempt was made to correct the deformity of the hyoid bone. Within two weeks his voice regained its normal pitch, and articulation and swallowing were accomplished without pain. Roentgenograms taken one month later showed firm bony union at the site of fracture.

#### SYMPTOMS AND SIGNS

The 2 cases reported show well the findings which are common to both muscular and traumatic fractures of the hyoid bone. Almost without exception pain of the neck and throat is the outstanding symptom. The pain is usually described as sharp and is made worse by talking and swallowing. The dysphagia is worse on an attempt to swallow solid foods than it is on swallowing liquids.

A change of voice (such as occurred in case 2) has been noted by other investigators<sup>6</sup> Complete aphonia has been reported in 1 case<sup>7</sup>, however, this was of a transitory nature and may have been hysterical The voice is usually lowered in pitch and may be reduced to a whisper Hoarseness commonly accompanies a change in voice but may occur alone<sup>8</sup>

Bloody sputum occurring a few hours after the fracture has been reported<sup>9</sup> This should always arouse a suspicion that the laryngeal box has been perforated by a bony fragment

Tumefaction of the neck such as that in case 1 has been reported by Ashe<sup>6a</sup> In his case the mass developed anteriorly in the neck, extending from above the hyoid bone to the mandible In case 1 the mass was below the hyoid bone Both fractures in which a mass developed were due to muscular action

In cases of fracture due to muscular action, the patient may describe a sensation of snapping or of "something giving" in the neck Point tenderness over the fracture site is commonly present but may be obscured in patients who have strangled (manual strangling or hanging), owing to the generalized pain present in the throat because of the nature of the trauma Subcutaneous emphysema was reported in 1 case<sup>6e</sup>

#### TREATMENT

For purposes of treatment cases of fracture of the hyoid bone may be divided into two groups (1) those in which a bony fragment perforates the larynx or the pharynx, and (2) those in which there is no perforation of the larynx or the pharynx It follows from this that in all cases of fracture of the hyoid bone a thorough examination of this region should be made

In the first instance reduction of the fragments is indicated This seems best accomplished by placing the index finger of one hand behind the tonsillar fossa on the side of the fracture and placing the other hand along the neck over the site of fracture Pressure is made on the index finger, and the fracture is reduced by pushing the bony fragment into

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6 (a) Ashe, H P Fracture of the Greater Cornu of the Hyoid Bone Resulting from Muscular Action, *J A M A* **61** 1618 (May 20) 1916 (b) Pearson, W W Fracture of the Hyoid Bone, *J Iowa M Soc* **8** 395 (Nov) 1918 (c) Harrell, V Fracture of Hyoid Bone, *Grace Hosp Bull* **13** 11 (Jan) 1929 (d) Ashby, E L A Case of Fracture of the Hyoid Bone, *Lancet* **1** 803 (June 28) 1918 (e) Kleinberg, S Fracture of the Hyoid Bone, *Ann Surg* **99** 547 (March) 1934

7 Hazlett, H P Fracture of the Hyoid Bone, *Med Fortnightly* **10** 504, 1896

8 Campbell, C B Fractura Ossis Hyoidi, *Times & Reg* **27** 51, 1894 Hazlett 7

9 Ashe 6a Kleinberg 6e

alignment with the remainder of the hyoid bone. The throat should then be examined with a mirror to make sure that no fragment protrudes into it. Following this the patient should have complete rest of voice and be given a liquid diet for at least one week.<sup>10</sup>

In reviewing the literature there can be little doubt that the completely conservative treatment is the treatment of choice for those fractures which do not perforate the larynx. No manipulation of any kind is necessary. The patient's voice is put at complete rest for at least one week. A liquid diet is usually in order until the patient can tolerate solids without pain on swallowing. If swelling is present cold packs may be advisable. In some cases (as in case 1) feeding by tube must be resorted to because of extreme dysphagia, however, these cases are extremely rare.

#### COMPLICATIONS

One common complication of fracture of the hyoid bone is nonunion. This apparently should cause no great alarm. There seems to be no evidence that nonunion of a fractured hyoid bone interferes in any way with the normal functioning of the hyoid apparatus. Da Costa<sup>10</sup> stated that a fracture of the hyoid bone should unite in about four weeks.

Local abscess has been reported as a complication by Harrell<sup>6c</sup> and Hamilton.<sup>4</sup> In the case reported in Hamilton's textbook, there was suppuration, and a necrotic fragment of bone was discharged through a fistulous tract in the neck. In Harrell's case, an abscess formed but was incised and drained, and the patient made an uneventful recovery. Both cases were reported before the widespread use of chemotherapy.

The change in voice and the hoarseness are usually temporary. However, Winslow<sup>11</sup> stated that occasionally the voice is changed for a long time or even permanently.

#### PROGNOSIS

The prognosis is uniformly good. When death occurs, it is usually due to concomitant injury of the head or of the cervical part of the spinal column as in the case reported by Ashby.<sup>6d</sup> The prognosis must be more guarded in those cases in which a bony fragment perforates the larynx. Here there is danger of edema of the glottis or suffocation due to bleeding into the trachea. However, there seems to be no justification today for the old belief that if the wound breaks through the mucous

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<sup>10</sup> DaCosta, J. C. *Modern Surgery, General and Operative*, ed. 9, Philadelphia, W. B. Saunders Company, 1925.

<sup>11</sup> Winslow, R. *Injuries and Diseases of the Hyoid Bone*, *Ann Surg* 45:575, 1907.

membrane the condition is fatal in 75 per cent of the instances as the discussers of Crebbin's paper<sup>12</sup> indicated

Cases of fracture of the hyoid bone are so rare that it is impossible to collect a large enough series to estimate the mortality accurately. If one includes only those cases of fracture of the hyoid bone reported in the literature without accompanying injury of the skull, of the cervical part of the spinal column or of the tracheal cartilages, the mortality rate is probably less than 2 per cent.

#### MUSCULAR FRACTURES

Fractures of the hyoid bone due to muscular action are of special interest because of the difficulty which sometimes arises in the diagnosis of this condition. Thus, Forbes<sup>13</sup> reports a case in which such a fracture occurred while the patient was eating meat. The attending physician thought the patient had a bone in the throat and spent two hours with a forceps trying to extract the tip of the greater cornu of the hyoid bone, which had perforated the larynx.<sup>1</sup>

The cause of muscular fracture of the hyoid bone is somewhat obscure. It has been suggested that patients with well developed musculature are apt to have this type of fracture. This does not seem to be the entire answer. As seen in table 1, 3 of the 5 patients whose cases have been reported were of the asthenic habitus, and 1 of these was described as both asthenic and undernourished.

It is of interest to note that on the roentgenograms of the neck in case 1 (fig 2) the hyoid bone casts a dense shadow and shows complete union between the greater cornu and the body. This is also seen on the roentgenogram in Kleinberg's<sup>6e</sup> paper. The patient in case 1 was 32 years old, while Kleinberg's patient was 21 years of age. According to Pancoast,<sup>14</sup> the greater cornu does not unite with the body of the hyoid bone until between the ages of 35 and 45 and may remain separated throughout life. The heavy shadow of the bone suggests unusual ossification and possibly heavy deposits of calcium. It appears likely that the joining of the greater cornua to the body of the hyoid bone early in life together with early complete or anomalous ossification may make this bone more brittle and predispose it to fractures from muscular action.

<sup>12</sup> Crebbin, J. T. Fracture of the Hyoid Bone, *South M J* **11** 642 (Sept) 1918.

<sup>13</sup> Forbes, S. B. Fracture of the Greater Cornu of the Hyoid Bone. Perforation of Pharynx, *J Florida M A* **17** 585 (June) 1931.

<sup>14</sup> Pancoast, H. K., Pendergrass, E. P., and Schaeffer, J. P. *The Head and Neck in Roentgen Diagnosis*, Springfield, Ill. Charles C Thomas, Publisher, 1940.



## SUMMARY

Two cases of fracture of the hyoid bone are presented. In one case the fracture was due to trauma, and in the other it was due to muscular action.

The literature is briefly reviewed and the diagnosis, the treatment, the complications and the prognosis are discussed.

It is suggested that early uniting of the greater cornua of the hyoid bone to the body together with anomalous ossification may predispose the bone to fracture from muscular action.

715 West Washington Street

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2 Christopher, F. A Textbook of Surgery, ed 3, Philadelphia, W B Saunders Company, 1942

# SALIVARY ADENOCARCINOMA OF THE NASOPHARYNX

## Report of a Case

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ROCHESTER, N Y

CANCER of the nasopharynx, with constantly improving methods of diagnosis, constitutes an ever increasing percentage of recognized malignant growths. Martin and Blady,<sup>1</sup> in 1940, found it to represent about 2 per cent of all malignant growths of the head and neck. This type of malignant growth seems to occur at an earlier age than does cancer in other parts of the body, a large percentage being seen in adolescents and young adults. Nasopharyngeal cancer also appears to be more frequently seen in the Far Eastern peoples, the Chinese especially.

The presenting symptoms of a nasopharyngeal tumor are usually cervical metastases, nasal obstruction, discharge, nasal bleeding, headache, local aural pain and unilateral defective hearing. Nasal obstruction occurs as an early symptom in about one third of the cases of nasopharyngeal tumor, while nasal discharge and bleeding are late secondary symptoms in over one-half the cases. Unilateral deafness or pain occurs as an initial symptom in about 10 per cent of the cases. As a later complication, pressure on the auditory nerve as a result of intracranial extension is often seen. Direct extension through the foramen lacerum subdurally is a frequent result of nasopharyngeal growth. The cranial nerves are usually affected in this order: sixth, third, fourth, fifth, seventh and second. Occasionally the eighth, ninth, tenth, eleventh and twelfth nerves also are involved by extension of the tumor. Nasopharyngeal tumors, in their growth into the cranial cavity, lie extradurally and cause erosion of bone by pressure. Intracranial extension is almost always the cause of death.

The appearance of any malignant nasopharyngeal growth varies with its duration, size and pathologic characteristics. The general physical characteristics, however, as seen with the nasopharyngoscope or post-nasal mirror, are these. The tumor generally arises from the fossa of

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<sup>1</sup> Martin, H E, and Blady, J V. Cancer of Nasopharynx, Arch Otolaryng 32: 692 (Oct) 1940

Rosenmuller and extends anteriorly, to the midline, and inferiorly. It is usually of a red, hypertrophic, fungating or rounded appearance and usually bleeds easily when it is touched with an applicator or when a specimen is removed for biopsy. It may or may not extend to or over the torus tubarius, causing obstruction of the eustachian tube, and it likewise may or may not extend to the point of causing a postchoanal obstruction. The appearance of a malignant nasopharyngeal growth differs considerably from that of a benign tumor, but biopsy of any suspicious lesion in this area, with the possible exception of fibroma, because of its extreme vascularity, is the only conclusive method of diagnosis. The importance of direct examination, with the nasopharyngoscope, of all growths of a suspicious nature cannot be stressed too strongly.

Adenocarcinoma of the salivary gland is rarely seen as a nasopharyngeal tumor. Ewing<sup>2</sup> expressed the belief that the cylindroma is a type of adenocarcinoma of the salivary gland and described it as being made up of anastomosing cords or broad masses of epithelial cells, enclosing spaces filled with mucus. There are coarse trabeculae, which may undergo hyaline or mucoid degeneration. Ewing apparently felt that the cylindroma is of a much lesser grade of malignancy than is the actual adenocarcinoma of the salivary gland.

Martin and Blady,<sup>1</sup> in a series of 87 cases of cancer of the nasopharynx, found 3 tumors which they classified as carcinoma of the salivary gland. Stout,<sup>3</sup> in his series of 82 nasopharyngeal tumors, 68 of which were malignant, found 2 cylindromas, solid type, and classified them as rare. Kasabach<sup>4</sup> likewise found, among 42 malignant tumors of the nasopharynx, 3 of the cylindromatous type. Ewing,<sup>5</sup> in a series of 110 cases of nasopharyngeal tumors, reported 3 instances of growths which he called "malignant adenoma," but he did not indicate the exact type. New and Stevenson,<sup>6</sup> in a series of 234 cases of malignant nasopharyngeal tumors, found 2 cases of adenocarcinoma and 5 cases of adenocarcinoma of the mixed type, but they did not indicate the exact type either. While these statistics might seem to show that cylindroma and adenocarcinoma make up a very small percentage of nasopharyngeal tumors, the following authors did not report a single case of cylindroma

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2 Ewing, J. *Neoplastic Diseases*, ed. 4, Philadelphia, W. B. Saunders Company, 1940.

3 Stout, A. P. *The Pathological Diagnosis of Nasopharyngeal Tumors*, *Laryngoscope* 51:446, 1941.

4 Kasabach, H. H. *Roentgenography of the Malignant Nasopharyngeal Tumors*. A Preliminary Report, *Laryngoscope* 51:459, 1941.

5 Ewing, J. *Radiosensitivity*, *Radiology* 13:313, 1929.

6 New, G. B., and Stevenson, W. *End Results of Malignant Lesions of the Nasopharynx*, *Arch. Otolaryng.* 38:205 (Sept.) 1943.

or salivary adenocarcinoma in their series New, Broders and Childray<sup>7</sup> (194 cases), Harmer<sup>8</sup> (365 cases), Crowe<sup>9</sup> and Baylor (40 cases), Heine<sup>10</sup> (19 cases) and Salinger and Pearlman<sup>11</sup> (24 cases)

The table indicates the actual incidence of the various types of tumors reported by different authors Epidermoid, squamous cell and other types of carcinoma are classified generally as carcinoma, while

*Incidence of Various Types of Nasopharyngeal Tumors*

Author	Total No of Cases Studied	Carcinoma or Epithelioma	Sarcoma	Endothelioma	Plasmacytoma	Malignant Adenoma	Cylindroma	Salivary Adenocarcinoma
Martin and Blady <sup>1</sup>	87	73	11					3
Crowe and Baylor <sup>9</sup>	40	16	24					
Stout <sup>3</sup>	68	45	10		1		2	
Kasabach <sup>4</sup>	42	30	8		1		3	
Heine <sup>10</sup>	19	13	6					
Salinger and Pearlman <sup>11</sup>	24	22	2					
New Broders and Childray <sup>7</sup>	194	154	40					
Harmer <sup>8</sup>	365	86	232	47				
Ewing <sup>5</sup>	110	91	15			4		
New and Stevenson <sup>6</sup>	234	184	43			7		
Total	1 183	724	391	47	2	11	5	3
Percentage	100	61.2	33	4	0.1	0.9	0.4	0.2

lymphosarcoma, angiosarcoma and other types of this class are listed as sarcoma Cylindroma is classified separately because it has a much lower grade of malignancy than does the actual salivary adenocarcinoma

The general confusion concerning classification renders exact differentiation extremely difficult, but, as can be seen from the table, salivary adenocarcinoma is one of the rare types of nasopharyngeal tumor As pointed out by Eggston,<sup>12</sup> mixed tumors of the salivary gland, adenocarcinoma and cylindroma as such, are not uncommon in the mouth,

7 New, G B, Broders, A C, and Childray, J H Highly Malignant Tumors of the Pharynx and Base of Tongue, Surg, Gynec & Obst 54 164, 1932

8 Harmer, W D The Relative Value of Radiotherapy in the Treatment of Cancer of the Upper-Air Passages (University of London Semon Lectures), London, John Murray, 1932, p 38

9 Crowe, S J, and Baylor, J W Benign and Malignant Growths of the Nasopharynx, Arch Surg 6 429 (March) 1923

10 Heine, L H Malignant Tumors of the Nasopharynx, Arch Otolaryng 22 51 (July) 1935

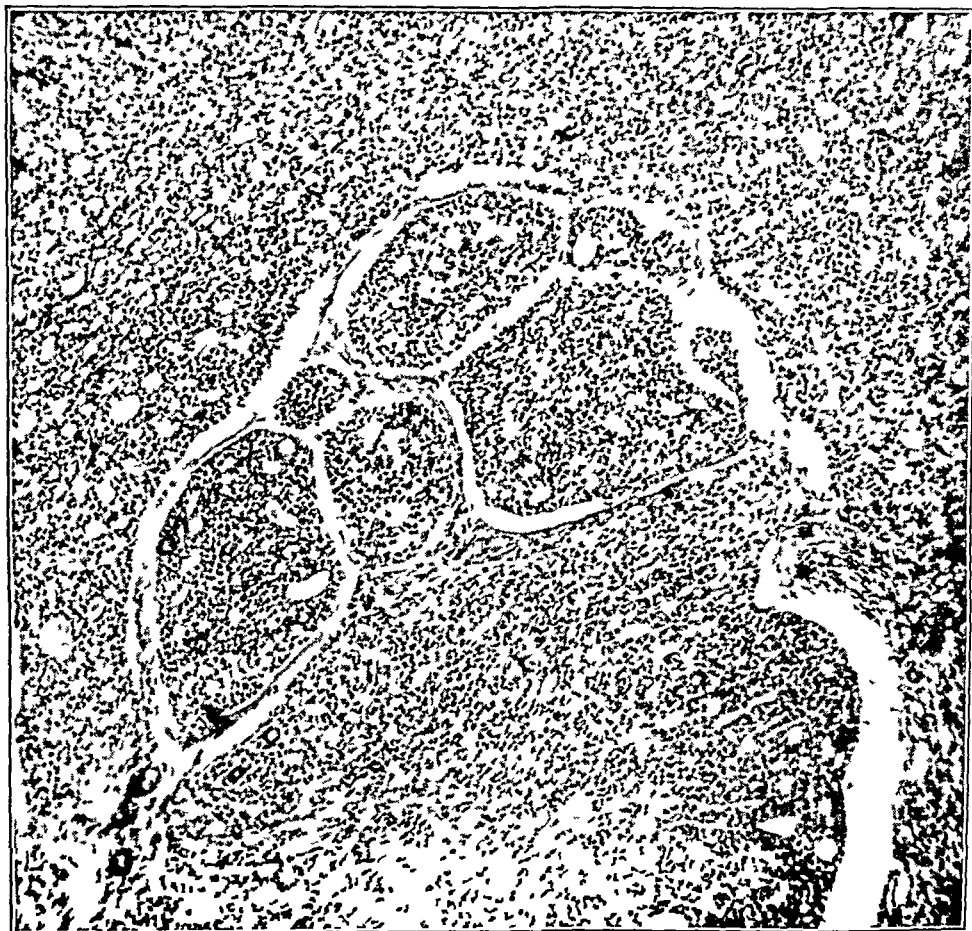
11 Salinger, S, and Pearlman, S J Malignant Tumors of the Epipharynx, Arch Otolaryng 23 149 (Feb) 1936

12 Eggston A A Tumors of the Nose and Nasopharynx, New York State J Med 43 2403, 1943

the hard and soft palate and the trachea. As an entity in the nasopharynx, however, both salivary adenocarcinoma and cylindroma are rare.

#### REPORT OF CASE

A well nourished white man, aged 34, was admitted to the outpatient department of the Strong Memorial Hospital with the chief complaint of difficulty in hearing in his left ear, of about four weeks' duration. At the onset of the deafness, his family physician had "blown out" his ear several times, with tem-



Low power section of the pathologic specimen. The cystic areas with the tumor acini can be seen in the center of the field.

porary relief. After several of these unsuccessful treatments the patient was referred to the clinic. At this time he was in good health except for the aforementioned complaint. The general physical examination showed a normal condition except for a slight enlargement of the prostate, the result of gonorrhea in 1944. The right ear drum appeared normal, but the left drum showed some retraction. The audiogram revealed an average loss of 30 to 40 decibels in all frequencies by air conduction in the left ear, with normal hearing in the right ear. Bone conduction was normal in both ears. The differential tuning fork test demonstrated a loss of air conduction in the left ear.

Nasopharyngoscopic examination revealed a reddened, fungating mass, about 2 to 3 cm long and 1 cm wide, extending from the fossa of Rosenmuller inferiorly and involving the left torus tubarius and partially occluding the left eustachian orifice. The lesion did not appear to extend past the middle or below the eustachian orifice inferiorly or beyond the anterior edge of the eustachian orifice. A specimen for biopsy was taken by the intranasal route under direct vision with the nasopharyngoscope. Bleeding was moderate. The microscopic picture was described in the pathologic report as being made up of circumscribed masses of hyalinized connective tissue (figure). There was a marked variation in the arrangement of cells. Here and there cords of tumor cells were observed with enclosed cystic spaces filled with mucoid material and with intervening dense hyalinized cells with cystic areas containing fibrillary, pink-staining material. Some tumor acini were seen. In some areas there appeared to be mucoid degeneration. Tumor cells were polygonal, with pleomorphic, hyperchromatic, basophilic and granular nuclei in scanty cytoplasm. There was a moderate amount of regular-appearing, aberrant salivary gland tissue scattered throughout. Collections of lymphoid tissue were seen. The pathologic diagnosis was carcinoma of an aberrant salivary gland of the left portion of the nasopharynx.

Treatment by excision, followed by intensive roentgen and radium irradiation by the Blady<sup>13</sup> applicator, was given. A depth dose of 4,108 r and 600 milligram hours of radium were given to the site of the tumor. There has been no further decrease of hearing in the left ear since the original audiogram was taken, and one year after the removal of the tumor, biopsy of a specimen from its site revealed no recurrence.

#### SUMMARY

Epidermoid or squamous cell carcinoma makes up the greatest percentage of nasopharyngeal cancers. A case report is presented to add to the literature an account of one of the rarer types of nasopharyngeal tumors, namely, salivary adenocarcinoma.

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13 Blady, J. V. New Instrument for Irradiation of Tumors of the Nasopharynx with Radium or Radon, *Am J Roentgenol* 40 723, 1938

## MODIFIED RADICAL MASTOIDECTOMY

Preservation of the Cholesteatoma Matrix, a Method of Making a  
Flap in the Endaural Technic

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THERE IS little that can be said about the modified radical mastoidectomy (modified tympanomastoidectomy, atticomastoidectomy, semiradical mastoidectomy, Heath mastoidectomy, Bondy mastoidectomy) that has not been said before. All that has been written, however, has not produced uniformity in the treatment of patients who present chronic otorrhea.

While I was on active duty with the United States Navy and closely associated with a considerable variety of specialists, it occurred to me that the differences of opinion were more extreme than seemed reasonable. As examples: Dangerous types of suppurative otitis media were dallied with when surgical intervention was indicated, the radical mastoidectomy was done on nondangerous ears when local treatment should have been more persistent, the radical mastoidectomy was done when the modified radical mastoidectomy would have sufficed. These divergent views are responsible for the present discourse.

The literature is full of opposing points of view relative to the treatment and the disposition of the persons who suffer from chronic otorrhea. The differences include local treatment versus surgical, the radical operation as against the modified, the choice of operation in the presence of a cholesteatoma and the postauricular versus the endaural technic.

There is, or was, a group of otologists who confined themselves to two operations for otorrhea, the simple and the radical, they were not interested in any modification of either.<sup>1</sup>

It has been suggested by a small number<sup>2</sup> that the modified radical

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Presented as a candidate's Thesis to the American Laryngological, Rhinological and Otolological Society, Inc., Nov. 1, 1946.

1 Page, J. R. Operative Treatment of Chronic Otorrhea, *Tr. Am. Otol. Soc.* **16**: 618-646, 1924.

2 (a) Morrison, W. Modern Conception of Treatment of Chronic Suppurative Otitis Media, *Ann. Otol., Rhin. & Laryng.* **51**: 5-21, 1942. (b) Smith, J. M. The Radical Mastoid Operation, *Arch. Otolaryng.* **13**: 28-36 (Jan.) 1931.

mastoidectomy be done without a meatal flap and treated through the postauricular wound

A few otologists<sup>3</sup> have expressed the belief that just as good hearing can be obtained with the radical as with the modified mastoidectomy

The majority<sup>4</sup> have held that the modified operation will result in better hearing than the radical

Some<sup>5</sup> have argued that the presence of a cholesteatoma necessitates radical surgical intervention Others have not agreed that a cholesteatoma contraindicates the modified radical operation<sup>6</sup>

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3 Dav E W, in discussion on Smith 5c

4 (a) Almour, R Surgery of Chronic Otorrheas in Kopetzky 20e (b) Ballenger, W L The Meato Mastoid Operation in Chronic Mastoiditis J A M A **51** - 1062-1070 (Sept 26) 1908 (c) Loeb, H W, and others Operative Surgery of the Nose, Throat and Ear, for Laryngologists Rhinologists Otologists and Surgeons, St Louis, C V Mosby Company, 1917, vol 2 (d) Blackwell, H B A Modified Radical Operation for Chronic Suppurative Otitis Media Based on Eight Cases, Ann Otol, Rhin & Laryng **25** 908 912, 1916 (e) Modified Radical Mastoid Operation for Cure of Chronic Otorrhea, Laryngoscope **39** 506 511 1929, (f) Conservative Operation for Chronic Mastoiditis, Tr Am Laryng, Rhin & Otol Soc **41** 488 494, 1935 (g) Buvinger, C W Problems in Modified and Radical Mastoid Operations, J M Soc New Jersey **30** 310 314, 1939 (h) Goodyear, H M The Radical Mastoid Operation Use of the Tensor Tympani Muscle in Closing the Eustachian Tube, Tr Am Otol Soc **29** 225 236 1939 (i) Henner, R Experiences with Endaural Complete Mastoidectomy and Atticomastoidectomy, Arch Otolaryng **31** 1022 1023 (June) 1940 (j) Jansen, A, in discussion on Ballenger 4b (k) Kopetzky, S J The Basic Factors Underlying Otitic Suppurations, in Kopetzky 20e (l) Lathrop, F D Endaural Atticomastoidectomy Evaluation, Tr Am Laryng, Rhin & Otol Soc, 1943, pp 236 248, Laryngoscope **53** 589 601, 1943 (m) Lillie, H I Indications for the Bondy Type of Modified Radical Mastoid Operation, Ann Otol, Rhin & Laryng **44** 337 343, 1935 (n) Neumann, H Die conservative Radikaloperation der chronischen Mittelohrentzündungen, Acta otolaryng, 1928, supp 7, pp 121 175 (o) Shambaugh, G E, Jr New Plastic Flap for Use in Endaural Radical Mastoidectomy Ann Otol, Rhin & Laryng **51** 117-121, 1942 (p) Simpson, W L Modified Radical Mastoidectomy The Indications and Technic (Semiradical Mastoidectomy, Modified Tympanomastoidectomy, Heath Mastoidectomy, Bondy Mastoidectomy), Arch Otolaryng **44** 157 159 (Aug) 1946 (q) Morrison 2a

5 (a) Heath, C J, cited by Richards 16 (b) Hempstead B E Operative Procedures in Chronic Suppurative Otitis Media with Mastoiditis, Minnesota Med **16** 615, 1933 (c) Smith, S M Otitic Cholesteatomata, Tr Am Otol Soc **16** 414 431, 1923 (d) Smith, S M, in Jackson C, Coates, G M, and Jackson, C L The Nose, Throat and Ear and Their Diseases, Philadelphia, W B Saunders Company, 1930 Cholesteatoma, p 539, The Modified Radical Mastoid Operation, p 542

6 (a) Shambaugh, G E, Jr Primary Skin Graft in Modified (Bondy) Radical Mastoidectomy for Preservation of Hearing in Cases of Genuine Cholesteatoma, Arch Otolaryng **23** 222 228 (Feb) 1936 (b) Tobey, G L, Jr Treatment of Chronic Suppurative Otitis Media Tr Am Laryng, Rhin & Otol Soc **33** 509 516, 1927 (c) Goodyear 4b



A number<sup>7</sup> of otologists have urged that the matrix of the cholesteatoma be preserved, others<sup>8</sup> have insisted that its removal be complete to insure a successful result

Of the otologists who have tried the endaural technic, a few<sup>9</sup> have minimized its advantages, but the majority<sup>10</sup> have conceded that it is the method of choice for both the modified radical and the radical mastoidectomy

The least disputed topic is the local treatment of the ears showing chronic otorrhea. It is generally agreed that local treatment should be given an extended, conscientious trial, provided that the apparent pathologic conditions are such that this conservatism will be of no risk to the patient

#### CHOLESTEATOMA

Since it is urged that the matrix of the cholesteatoma be preserved, the following information is presented

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7 (a) Babbitt, J. A. Chronic Infection of the Middle Ear, in Jackson and Jackson<sup>21</sup> (b) Dundas Grant, J., cited by Goldsmith, P., in discussion on Smith<sup>5c</sup> (c) Kopetzky, S. J. Cholesteatoma, *Laryngoscope* **43** 118 131, 1933 (d) Siebenmann, F. Die Radical operation des Cholesteatoms mittelst Anlegung breiter permanenter Oeffnungen gleichzeitig gegen den Gehorgang und gegen die retroauriculare Region, *Berl klin Wchnschr* **30** 12, 1893, (e) Ueber die Knorpelresection, eine neue Modification des Kornerschen Verfahrens bei der Cholesteatoma-operation, *Ztschr f Ohrenh* **33** 185-191, (f) Toti, E. Sull' operazione radical per la via del condotto uditivo, secondo Heermann, *Oto rino laring ital* **4** 49 56, 1934 (g) Almour<sup>4a</sup> (h) Goodyear<sup>4b</sup> (i) Tobey<sup>6b</sup>

8. Heath<sup>5a</sup> Lathrop<sup>41</sup> Simpson<sup>4p</sup> Smith (footnote 5c and d)

9 Brunetti, F. Contributo allo studio della antrotomia epitimpanale, *Arch ital di otol* **43** 449 474, 1932, Ancora sull antrotomia epitimpanale, *ibid* **43** 692 693, 1932 Wishart, D. E. S. The Endaural Route, *Tr Am Otol Soc* **29** 200 224, 1939

10 (a) Babbitt, J. A. Endaural Surgery of Chronic Suppurations, in Kopetzky<sup>20e</sup> (b) Guns, P. La cure radicale des otorrhees chroniques par le conduit et ses resultats physiologiques, *Rev de laryng* **54** 1102 1131, 1933 (c) Johnson, L. F., and Zonderman, B. Experiences with Endaural Surgery Preliminary Report, *Arch Otolaryng* **33** 1004 1007 (June) 1941 (d) Kettel, K. Lempert Endaural, Antauricular Surgical Approach to Temporal Bone Suggested Modification of Technic in Tympanomastoidectomy, Report of Fifty-Five Cases, *ibid* **34** 461 472 (Sept) 1941 (e) Lempert, J. Endaural, Antauricular Surgical Approach to the Temporal Bone, *ibid* **27** 555 587 (May) 1938 (f) McCurdy, G. J. Endaural Mastoidectomy Five Years Experience, *Laryngoscope* **55** 349 370, 1945 (g) Thies, F., Jr. Die Radikaloperation durch den ausseren Gehorgang, *Ztschr f Hals-, Nasen- u Ohrenh* **33** 459 475, 1933 (h) Williams, H. L. Antauricular Approach in Radical Mastoidectomy Suggestions of New Plastic Closure of Wound, *Proc Staff Meet, Mayo Clin* **17** 22-24, 1942 (i) Woodruff, G. Observations on the Endaural Mastoidotomy of Lempert, *Arch Otolaryng* **31** 1024 1025 (June) 1940 (j) Henner<sup>41</sup> (k) Lathrop<sup>41</sup> (l) Shambaugh<sup>40</sup>

Cholesteatoma<sup>11</sup> is a tumor which is surrounded by a thin shell of epidermis and connective tissue and in which is accumulated desquamated horny epithelium. There are considered to be two main types (Wittmaack<sup>12</sup>) (1) true cholesteatoma and (2) pseudocholesteatoma. The latter is subdivided into (a) the primary or genuine type and (b) the secondary type.

*True Cholesteatoma*—This tumor is considered to be derived from an embryonic rest and consists of concentric polygonal lamellas, composed of epidermoid cells which are devoid of nuclei.<sup>7c</sup> Between these lamellas are found cholesterol crystals in greater or lesser quantity. Surrounding the mass is a membrane, the cholesteatoma matrix, which has an outer layer of connective tissue attached to bone and an inner epidermal layer. There is no recognizable difference pathologically between the true and the pseudocholesteatoma.

The true cholesteatoma (pearly tumor) is found in the skull, not associated with the ear. Such a tumor was described by Cushing,<sup>13</sup> who ventured the opinion that in ears true cholesteatoma rather than pseudocholesteatoma may be the rule and that the cholesteatoma is responsible for otitis media, rather than the reverse. Except for the primary type of pseudocholesteatoma, it is unlikely that any otologist will support Cushing's view.

*Pseudocholesteatoma*—The primary or genuine type is thought to come from a spontaneous perforation of Shrapnell's membrane (membrana, or pars, flaccida of the tympanic membrane). The perforation itself is the result of marked epitympanic absorption of air from a shutting of the tubotympanic space by adhesive bands that are thought to occur in the course of otitis neonatorum. From the margins of the perforation epithelium invades the attic of the tympanum (epitympanum) and the antrum of the mastoid process and, with accumulation of the trapped products of desquamation, the pseudocholesteatoma gradually enlarges, causing pressure rarefaction of the underlying bone. This type is usually seen only when secondary suppuration occurs or when complications arising from intracranial pressure cause death.

11 (a) Almour, R. The Significance of the Squamous Epithelium in the Cause and Repair of Chronic Middle Ear Disease, *Tr Am Acad Ophth* **35** 357-377, 1930. (b) Ersner, M. S. The Diagnosis of Otitic Surgical Lesions, in Kopetzky<sup>20e</sup>. (c) Lange, W. Tief eingezogene Membrana flaccida und Cholesteatom, *Ztschr f Hals, Nasen- u Ohrenh* **30** 575-582, 1932. (d) Kopetzky<sup>7c</sup>. (e) Shambaugh<sup>6a</sup>. (f) Smith<sup>5c</sup>.

12 Wittmaack, K. Ueber die normale und die pathologische Pneumatisation des Schläfenbeines, Jena, G. Fischer, 1918.

13 Cushing, H. A Large Epidermal Cholesteatoma of the Parieto Temporal Region Deforming the Left Hemisphere Without Cerebral Symptoms, *Surg, Gynec & Obst* **34** 557-566, 1922.

The secondary type of pseudocholesteatoma is the sequel of a chronic otitis media in which the epithelium from the external auditory canal or from the margin of the tympanic membrane invades the middle ear or the epitympanum and the antrum of the mastoid process. It progressively increases in size in the pattern described for the primary type of pseudocholesteatoma.

#### REMOVAL VERSUS PRESERVATION OF THE CHOLESTEATOMA

Some otologists<sup>14</sup> are vehement in their insistence that all vestiges of the cholesteatoma be removed or that the mere presence of a cholesteatoma<sup>15</sup> calls for radical surgical operation. S. MacCuen Smith<sup>5d</sup> stated

In general, it is a safe rule to follow that the radical mastoid operation is indicated if the diagnosis of cholesteatoma is made, or even if there is a strong probability of its presence. Latterly, some authorities regard the collection of a cholesteatomatous mass as malignant in character, this being an additional indication for its complete eradication so far as possible.

Again, Smith<sup>5c</sup> said

unquestionably the removal of the epidermal membrane is the crux of the procedure and this can only be accomplished before the cyst is emptied of its contents and its enveloping membrane permitted to collapse. Incomplete removal of the lining wall is doubtless the explanation of recurrences so common after operation by otologists for the cholesteatoma of the temporal bone.

Richards,<sup>16</sup> in reviewing the Heath operation, stated

If cholesteatoma be present, the ear is, in Mr. Heath's opinion, doomed, as he has never seen a cessation of suppuration with cholesteatoma incompletely removed from the attic.

Perry Goldsmith,<sup>17</sup> in the discussion of Smith's paper, stated

The study of this disease (cholesteatoma) is closely associated with the name of Sir James Dundas Grant. He tries to preserve the matrix in cholesteatoma cases. I have tried this but not successfully.

Gruber,<sup>18</sup> as well as other early authors, expressed the belief that cholesteatomatous formations are malignant. More recent commentators have considered them primarily benign. The tumor itself is not malignant. It threatens life only when it grows into vital cranial structures.

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14 Ballenger 4b Heath 5a Hempstead 5b Lathrop 41 Simpson 4p Smith (foot note 5c and d)

15 Day 3 Heath 5a Hempstead 5b Smith 5c

16 Richards, G. L. The So Called Conservative Mastoid Operation, with a Description of the Technic of Heath, Bondy and Siebenmann, *Ann. Otol., Rhin. & Laryng.* 20: 578-594, 1911.

17 Goldsmith, P., in discussion on Smith 5c

18 Gruber, cited by Smith 5c

Recorded among those whose experiences disprove the necessity of removing the cholesteatoma matrix are Almour,<sup>4a</sup> Babbitt,<sup>7a</sup> Goodyear,<sup>4b</sup> Dundas-Grant,<sup>7b</sup> Kopetzky,<sup>7c</sup> Shambaugh Jr.,<sup>6a</sup> Seibenmann,<sup>7d,e</sup> Tobey<sup>6b</sup> and Toti<sup>7f</sup>

Those who have advocated complete removal of the matrix conceded that removal is difficult.<sup>2a</sup> But why remove it? If one considers the cholesteatoma as an epithelial cyst (Wolff<sup>19</sup>), which it is, why should one not utilize the well entrenched matrix of squamous epithelium in attaining the ultimate goal—complete epithelization of the new cavity? The danger from the cholesteatomatous cyst is gone once the cyst is adequately opened and the factor of pressure eradicated.

Almour<sup>4a</sup> presented a lucid rationale for preservation of the cholesteatoma matrix as follows:

A cholesteatoma is the frustration of nature's attempt to heal a dangerous chronic suppurative otitis media in that the desquamated products of the ingrowing epidermis are not afforded free access for discharge. In this manner, these dead epidermal cells accumulate to form a tumor mass, which by virtue of a continual need for expansion to accommodate their increasing bulk cause a pressure rarefaction of the surrounding bone. In this way, additional room is constantly being created for the growing mass of desquamated cells, which mass increases at the expense of the underlying bone. Once egress has been afforded to the products of desquamation, the element of pressure is relieved by the stoppage of accumulation; the growth of the tumor ceases, and the destruction of bone is brought to an end.

Consequently, unless the cholesteatoma has invaded the brain or produced a septic thrombus of the sigmoid sinus or bulb, or there is presented a suppurative labyrinthitis, the tympano mastoidectomy should be limited to the removal of the tumor mass *leaving the matrix in situ*, in both the mastoid process and tympanic cavity.

It is true that the epidermal layer of the cholesteatomatous matrix has long been subject to irritation from its superimposed collection of dead cells; but, during the course of the after care, this eczematous condition is soon controlled, and the squamous epithelium returned to normal.

Where a cholesteatoma, by the process of bone rarefaction that accompanies it, has produced a labyrinthine fistula without causing a suppuration of the labyrinth *per se*, the removal of the matrix which covers this fistula may be the cause of creating a pathway for infection into the interior of the membranous labyrinth. Where the pressure rarefaction of the cholesteatoma has been in the direction of the fallopian canal, horizontal or vertical, and a gradual increasing impairment of the seventh nerve is evident, the removal of the matrix may be the factor which will produce a permanent paralysis of the nerve. Where the lateral sinus asymptotically is partially or wholly obliterated by an invasion of a cholesteatoma into its lumen, the removal of the matrix may be the inciting incident in the appearance of a general sepsis. Therefore, it is unwise to disturb the matrix.

The matrix epithelium, after healing has taken place, will be indistinguishable from the rest of the epithelium that covers the meato-mastoid cavity.

19 Wolff, D. Personal communication to the author.

Preservation of the matrix was advocated as far back as 1893, by Siebenmann<sup>7d</sup>

I have been utilizing the matrix of the cholesteatoma in most cases, including both radical and modified radical operations, since 1933, and can attest to the soundness of the procedure. Exceptions are in revisions of previous radical or modified radical operations. In these cases there is the possibility that secondary subepithelial cholesteatomatous cysts may develop from remnants of the matrix—it is assumed, of course, that the previous operator had attempted complete removal of the cholesteatoma.

#### THE MODIFIED RADICAL MASTOIDECTOMY

This procedure is not given the emphasis which it deserves in the textbooks.<sup>20</sup> One of the newer volumes<sup>21</sup> gives it only a few lines. The otologic trainee, besides being "spoon fed" by his preceptors, acquires much of his basic knowledge from these very texts. He thus gains an inadequate impression of the scope of usefulness of this operation.

Among the names associated with the modified radical mastoidectomy are those of Ballance,<sup>22</sup> Ballenger,<sup>4b</sup> Bárány,<sup>23</sup> Bondy,<sup>24</sup> Bryant,<sup>25</sup> Blackwell,<sup>4d</sup> Heath,<sup>26</sup> Jansen,<sup>4j</sup> Korner,<sup>27</sup> Manasse,<sup>23</sup> Neumann,<sup>4n</sup> Panse,<sup>28</sup>

20 (a) Dench, E. B. *Diseases of the Ear*, New York, D. Appleton & Company, 1899. (b) Ballenger, W. L. *Diseases of the Nose, Throat and Ear*, Medical and Surgical, revised by H. C. Ballenger, ed. 6, Philadelphia, Lea & Febiger, 1930. (c) Keeler, J. C. *Modern Otolology*, Philadelphia, F. A. Davis Company, 1930. (d) Jackson, C., Coates, G. M., and Jackson, C. L. *The Nose, Throat and Ear and Their Diseases*, Philadelphia, W. B. Saunders Company, 1930. (e) Kopetzky, S. J. *Surgery of the Ear*, New York, Thos. Nelson & Sons, 1938. (f) Loeb.<sup>4c</sup>

21 Jackson, C., and Jackson, C. L. *Diseases of the Nose, Throat and Ear, Including Bronchoscopy and Esophagoscopy*, Philadelphia, W. B. Saunders Company, 1945.

22 Ballance, C. A., and Green, C. D. *Essays on the Surgery of the Temporal Bone*, London, The Macmillan Company, 1919, vol. 2.

23 Barany, cited by Mollison, W. M. *Brief Survey of the History of the Mastoid Operation*, *J. Laryng & Otol* **45**: 95-101, 1930.

24 (a) Bondy, G. *Totalaufmeisselung mit erhaltung von Trommelfell- und Gehörknöchelchen*, *Monatschr. f. Ohrenh.* **44**: 15-23, 1910. (b) *Die Behandlung der chronischen Mittelohrentzündung*, *Wien klin. Wchnschr.* **46**: 1390-1393, 1933.

25 Bryant, W. S. *Radical Mastoid Operation Modified to Allow the Preservation of Normal Hearing*, *Tr. Am. Otol. Soc.* **10**: 292-295, 1905.

26 (a) Heath, C. J. *The Cure of Chronic Suppuration of the Middle Ear Without Removal of the Drum or Ossicles or the Loss of Hearing, with Ten Cases*, *Lancet* **2**: 353-357, 1906. (b) Ellet, E. C. *The Heath Operation for Chronic Aural Suppuration*, *Laryngoscope* **19**: 567-572, 1909.

27 Kopetzky, S. J. *A Critique of the So Called Modified Radical Mastoid Operation*, *Am. Med.* **4**: 141-145, 1909.

28 Panse, R. *Stacke's Operationsmethode zur Freilegung der Mittelohrräume während des ersten Jahres ihrer Anwendung in der Ohrenklinik zu Halle a. S. vom 14. Januar 1891 bis 14. Januar 1892*, *Arch. f. Ohrenh.* **34**: 248-280, 1892-1893.

Richards,<sup>16</sup> Scheibe,<sup>29</sup> Stacke<sup>30</sup> and Seibenmann<sup>7d,e</sup> Kopetzky<sup>27</sup> credited Jansen and Korner with being the first to try it

In this country, Heath,<sup>26a</sup> in 1906, stirred up interest in the modified radical mastoidectomy and, paradoxically, also thwarted it. As pointed out by Kopetzky,<sup>27</sup> his indications were not delineated, he performed the operation in some cases in which a simple mastoidectomy would have sufficed. Plummer and Mosher<sup>31</sup> had the opportunity of observing 7 patients on whom Heath had performed the operation in this country. Their observations did not produce enthusiasm for the Heath procedure.

Richards<sup>16</sup> made a detailed comparison of the Heath, Seibenmann and Bondy operations. The fundamental difference was that Bondy removed the external attic wall (bridge, annulus tympanicus, sulcus tympanicus).

As time went on and the indications became more defined, the operation gained popularity in this country, so that today it is a standard (but not standardized) procedure. Most otologists approach the mastoid process through a postauricular incision, but the endaural extracartilaginous approach of Lempert is gaining popularity. Except for a few<sup>2</sup> who have advocated treating the ear through a postauricular wound with no meatal flap, most surgeons close the postauricular wound, when one has been made, and carry on the required treatment through a meatal flap. Nearly all connect the mastoid cavity, the mastoid antrum and the epitympanic space, to make one cavity. Some<sup>32</sup> remove the external attic wall, others<sup>33</sup> do not.

I consider the removal of the external attic wall an important step in obtaining a successful end result.

*Purpose of Operation*—The purpose<sup>34</sup> of the modified radical mastoidectomy is

- 1 To remove the dangerous lesion
- 2 To preserve or improve the hearing by preserving what remains of the ossicular chain and the tympanic membrane
- 3 To produce a dry ear (Primarily, the intention is to produce first a safe and useful ear and then a dry one.)

<sup>29</sup> Scheibe, cited by Sonnenschein, R. A Brief Consideration of the History of the Development of Mastoidectomy, Surg., Gynec. & Obst. **62** 523 (no 2A) 1936

<sup>30</sup> Stacke, L. Ueber eine neue Methode der Plastik zur Deckung der bei der operativen Friclegung der Mittelohrraume entbloßten Knochenflächen, Berl. klin. Wchnschr. **32** 840-841, 1895

<sup>31</sup> Plummer, E. M., and Mosher, H. P. A Report of Seven Cases Operated upon by Mr. Heath, Tr. Am. Otol. Soc. 1913, pp. 196-233

<sup>32</sup> Blackwell,<sup>4d</sup> Bondy<sup>24a</sup> Jansen<sup>4j</sup> Lathrop<sup>4l</sup> Simpson<sup>4p</sup>

<sup>33</sup> Shambaugh, G. E. Treatment of Chronic Suppurative Otitis Media, Tr. Am. Laryng., Rhin. & Otol. Soc. **34** 364-368, 1928. Bryant<sup>25</sup> Heath<sup>5a</sup>

<sup>34</sup> Almour<sup>4a</sup> Blackwell<sup>4d</sup> Bondy<sup>24a</sup>

- 4 To unite the external canal, the epitympanum, the antrum and the mastoid cavity into one cavity capable of draining spontaneously through an adequate meatal opening
- 5 To preserve this cavity and prevent its obliteration by causing it to be lined with squamous epithelium

*Indications for Operation*—It is generally agreed that surgical intervention is not indicated in all cases of chronic suppurative otitis media

Chronic otitic suppurations are best divided into two types<sup>35</sup> (1) the nondangerous and (2) the dangerous

The nondangerous suppuration occurs in an ear with a central perforation of the tympanic membrane. A central perforation may be defined as one in which there is still a margin of tympanic membrane at the annulus.<sup>2a</sup> The nondangerous suppuration is the result of a constant or recurring infection of the lining membrane of the tympanic cavity and is not dangerous to life.

The dangerous suppuration occurs in an ear with a marginal perforation of the tympanic membrane<sup>36</sup> and represents a lesion which destroys bone and endangers life. A marginal perforation may be defined as one which at some point has no drum membrane and has eroded the annulus. The small marginal perforation occurs in Shrapnell's membrane, either anteriorly or posteriorly. Shrapnell's membrane may be entirely missing. In a posterosuperior marginal perforation, the adjacent bony canal wall may be eroded away.

In cases in which a marginal perforation involves a considerable portion of the pars tensa of the tympanic membrane, there may be slowly progressive necrotic otitis media. (This includes the postscarlatinal, tuberculous, syphilitic, granulomatous and malignant lesions.)

The smaller marginal perforations, which usually involve only the pars flaccida but occasionally include the upper portion of the pars tensa, are the source of the squamous cell epithelium which invades the epitympanum, the antrum and other structures to form cholesteatoma. Often, the medial layer of the cholesteatoma, with its extension from the lower margin of the perforation of the tympanic membrane, seals off the structures in the tympanic cavity. This type is particularly suited for the modified radical mastoidectomy and the preservation of the matrix of the cholesteatoma. The dangerous portion of the lesion is removed when the epitympanum and the antrum and adjacent areas are opened up widely and cleaned out.

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35 Ernsner, M. S. Mastoiditis and Sinus Phlebitis, in Jackson and Jackson 21  
Almour 4a. Ernsner 11b. Morrison 2a.

36 Heatly, C. A. Chronic Diseases of the Nose, Throat and Ear, M. Clin North America 28 330 338, 1944.

Cholesteatoma does not occur in all cases of marginal perforation. In the cases in which it has not developed, the hearing may be good, even though the ossicles may be encompassed by granulations. It is not dangerous to do a modified radical mastoidectomy in such cases. Once the mastoid bone and the attic are opened up and completely cleaned out, the granulations around the ossicles will often disappear and a dry ear be obtained. If, however, the end result is not satisfactory, a radical operation can be done.

*Types of Operation*—If surgical intervention is to be limited to the dangerous type of suppurating ear, it remains for one to choose the operation best suited. This may be a radical mastoidectomy, a modified radical mastoidectomy or the even more conservative ossiculectomy. That the latter procedure has a place is vouched for by Tobey<sup>6b</sup> and Babbitt,<sup>37</sup> but it is not within the scope of this paper to discuss the ossiculectomy.

I prefer the modified radical mastoidectomy because of its wider range of usefulness and its greater margin of safety.

Since the dangerous otorrhea is in the ear that has a marginal perforation and the latter more often involves the pars flaccida or the upper or the posterior part of the pars tensa, *it is logical to expect the modified radical mastoidectomy to be indicated more often than the radical*. This expectation is fulfilled in my experience. I have performed the modified radical mastoidectomy on considerably more ears than the radical mastoidectomy (Lillie<sup>4m</sup> stated, "Better results have been obtained in my hands from use of the Bondy type of modified radical mastoid operation in certain selected cases than from the use of the typical radical mastoid operation in similar cases." Goodyear,<sup>4h</sup> for eighteen years, in all his cases in which there was a small perforation in Shrapnell's membrane, limited the operation to a modified radical mastoidectomy.) In the literature, in reports of series of cases in which chronic otorrhea was surgically treated,<sup>38</sup> the cases in which the radical mastoidectomy was performed far outnumber those in which the modified radical mastoidectomy was done. This as contrasted with my own studies suggests that possibly the modified radical operation has not been given the latitude which it deserves.

*Situations Which Determine the Selection of the Modified Radical Mastoidectomy*—There are nine types of cases to be considered.

1 Cases in which dangerous chronic otorrhea has been present for several months to several years, in which the pathologic process is limited

<sup>37</sup> Babbitt, J. A. Some Studies on Middle Ear Infection, JAMA 99 2241-2247 (Dec 31) 1932, Surgery in Chronic Middle Ear Infection, Ann Surg 101 407-410, 1935, footnote 7a

<sup>38</sup> Henner <sup>11</sup> Kettel 10d



more to the epitympanic space and surrounding antral area and in which pus is coming from a marginal defect of Shrapnell's membrane or posteriorly through bone from the tympanic antrum but this defect appears to be too small to permit adequate local treatment<sup>39</sup> Such a case may include cholesteatoma, the presence of which can be determined by the presence of the malodorous, flaky discharge and by roentgen examination, though in the latter it is often missed (The Mayer position for making roentgenograms of the mastoid process is said to be more revealing<sup>40</sup> and should be used )

2 Cases of dangerous chronic otorrhea in which the hearing is good or just a little diminished

3 Cases in which it is reasonable to suppose that continued discharge will cause diminution of hearing in the affected ear

4 Cases similar to 1 and 2 in which the hearing is not so good but the drum is more or less intact

5 Cases of recurrent mastoiditis in which there has been previous surgical treatment and in which the posterior wall of the external auditory canal has collapsed, leaving a slitlike opening

6 Cases with symptoms of urgency,<sup>41</sup> namely, headache on the affected side, nausea, vomiting, loss of equilibrium, nystagmus, mental dulness, sudden cessation of the aural discharge, a positive reaction to the fistula test and sudden onset of an elevation of temperature of the septic type These symptoms of urgency do not necessarily require the radical mastoidectomy In many cases the modified radical operation will be adequate

7 Age The nature of the lesion rather than the age of the patient should determine the choice of surgical procedure Youth and advanced age are not contraindications In fact, this should be considered a rehabilitation procedure in young children, many of whom have chronic otorrhea with attic perforation and cholesteatoma

8 Cases of exostosis of the external auditory canal, with or without chronic otorrhea<sup>41</sup> (With the endaural antauricular approach, it is possible to remove some exostoses with electrically driven burrs without opening up the mastoid cells )

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39 Almour 4a Lillie 4m

40 Danelius, G The Value of the Axial Projection of the Petrous Bone in the Diagnosis of Chronic Mastoiditis and Cholesteatoma, *Radiology* **43** 492-498, 1944 Fletcher, H A, and Windholz, F Roentgenology in Chronic Mastoiditis, *California Med* **66** 331-337, 1947

41 Page, J R The Report of a Case of Chronic Suppurative Otitis Media with Labyrinthine Symptoms and the Report of an Operation for the Removal of Exostoses of the External Auditory Canal, with Some Remarks on the Modified Radical Mastoid Operation, *Laryngoscope* **34** 497-500, 1929

9 Any case of chronic otorrhea of the dangerous type in which the other ear is deaf

*The Endaural Antauricular Approach*—In the performance of mastoidectomy the intrameatal technic is by no means new. An excellent historical review was given by Babbitt,<sup>10a</sup> who credited R. Kessel, of Jena, with starting intrameatal surgical operation in 1871. Others mentioned in the studies of the development of endaural procedures are Grunert,<sup>42</sup> Schwartze,<sup>42</sup> Schroeder,<sup>42</sup> Panse,<sup>28</sup> Jack,<sup>42</sup> Hoffman,<sup>42</sup> Lowe,<sup>42</sup> Hartmann,<sup>42</sup> Neumann,<sup>43</sup> Carlowitz,<sup>44</sup> von Gyergyay,<sup>45</sup> von Eicken,<sup>42</sup> Schmidt,<sup>42</sup> Guns,<sup>10b</sup> Mygind,<sup>42</sup> Barnett,<sup>42</sup> Hussburg,<sup>42</sup> Krampitz,<sup>46</sup> Lange,<sup>11c</sup> Schultze,<sup>42</sup> Botey,<sup>47</sup> Lempert,<sup>10e</sup> Zavaska,<sup>42</sup> Tobey<sup>6b</sup> and Heermann.<sup>48</sup>

The use of electrically driven burrs is not a new procedure. Botey<sup>47b</sup> reported that he had been using electric reamers since 1907.

The credit for popularizing the endaural operation and the use of the electrically driven burr in this country belongs to Julius Lempert,<sup>10e</sup> who devised a thoroughly adequate approach.

There have been many arguments for and against using the endaural technic in the surgical treatment of acute lesions of the mastoid bone, but it is generally agreed that the endaural approach is the ideal one for the modified radical and the radical mastoidectomy. It gives adequate exposure, affords the most direct view of the tympanic membrane and the epitympanic areas, and offers less trauma to the soft tissues, thereby diminishing the postoperative discomfort.

The use of the electrically driven burr advocated by Lempert is a refinement that is appreciated by those who have heretofore used gouges and chisels on the heavy sclerotic cortex and small mastoid cavities that are usually present. The "labor" of the operation is reduced practically to nil, and working in the small spaces, angles and curves is immeasurably facilitated.

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42 Cited by Babbitt 10a

43 Cited by Knecht, B. Erfahrungen über die Radikaloperation durch den Gehörgang, Monatschr f Ohrenh **70** 1025-1033, 1936

44 Carlowitz, H. Totalaufmeisselung des Mittelohres vom Gehörgange aus, Arch f Ohren, Nasen- u Kehlkopf **103** 73 88, 1919

45 von Gyergyay, A. Radikale Operation des Mittelohres vom Gehörgang aus mit Instrumenten, die von innen nach aussen Arbeiten, Ztschr f Hals, Nasen- u Ohrenh **6** 387-394, 1923

46 Krampitz. Bemerkungen zur Radikaloperation vom Gehörgang aus, Ztschr f Laryng, Rhin **17** 96 98, 1928

47 Botey, R. (a) Die Verhütung von Gehörgangsstenose nach der Radikaloperation, Ztschr f Ohrenh **49** 78-79, 1905, (b) Ma technique pour la trepanation de l'oreille, Ann d mal de l'oreille, du larynx **46** 45 48, 1927

48 Heermann, H. Zur Radikaloperation durch den operativ erweiterten Gehörgang, Ztschr f Hals-, Nasen-, u Ohrenh **36** 346-349, 1934

The incision to be described is a modification of Lempert's in which three incisions are used to remove a triangular piece of skin (fig 1) I save this piece of skin by using a single S-shaped incision (see insert in fig 2A) and utilize the outer, membranous part of the external auditory canal as an independent flap which serves as an additional source of epithelium to line the modified radical mastoidectomy cavity (fig 2C)

The idea for this incision was obtained from Drs R C McNaught and L Shahnian, of Stanford University Medical School

The utilization of the skin of the deep portion of the membranous part of the canal is an adaptation of the flap technic that Lempert has devised for his endaural fenestration operation for otosclerosis<sup>49</sup>

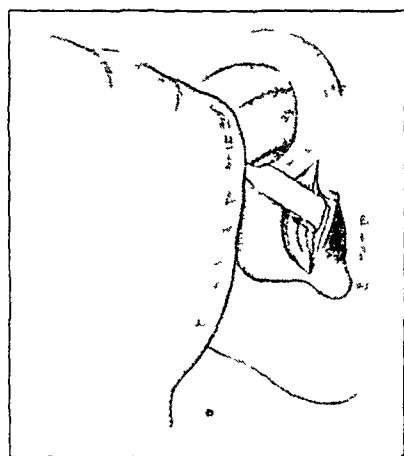


Fig 1—The three incisions used by Lempert in his fenestration operation. A triangular piece of skin is being removed. (This illustration is used with the permission of Dr Julius Lempert.)

Since epithelization of the modified radical mastoidectomy cavity is the ultimate goal of the modified radical mastoidectomy, it is not surprising that several otologists<sup>50</sup> have independently devised skin-saving incisions. Nor is it surprising that, realizing the usefulness and leeway of Lempert's canal flap, otologists have, with variations, utilized it in the modified radical mastoidectomy.

In reviewing the literature, it has been learned that Kettel<sup>10d</sup> described an endaural incision identical with the one which I presently use and that Shambaugh Jr<sup>40</sup> and Lathrop<sup>41</sup> have described similar flaps made from the skin of the external auditory canal.

**Anesthesia**—Local anesthesia or any type of general anesthesia may be used. If local anesthesia (1 per cent procaine hydrochloride solution

<sup>49</sup> Lempert, J. Improvement of Hearing in Cases of Otosclerosis. A New One Stage Surgical Technique, *Arch Otolaryng* **28** 42-97 (July) 1938.

<sup>50</sup> Matis, E. I. Practical Points in Transconchal Radical Mastoidectomy, *Arch Otolaryng* **33** 177-192 (Feb.) 1941. Kettel<sup>10d</sup> Williams<sup>10b</sup>

with 7 drops of 1 1,000 epinephrine solution to the ounce) is used, it is desirable to give sufficient preoperative medication to lull the patient into a dreamy state. A suggestion for adults is 3 grains (0.19 Gm) of pentobarbital sodium the night before operation, 3 grains of pentobarbital sodium two hours before operation, 1/4 grain (0.016 Gm) of morphine sulfate and 1/150 grain (0.43 mg) of scopolamine hydrobromide one hour before operation. The administration of 1/6 to 1/4 grain (0.011 to 0.016 Gm) of morphine sulfate may be repeated during the operation if required.

For general anesthesia, an ether—nitrous oxide—oxygen mixture may be administered by intratracheal tube, a “pentothal” sodium solution may be injected intravenously or ether may be given by the open drop method, especially with children.

Recently I have used a local anesthetic plus intravenous morphine sulfate alternated with intravenous meperidine hydrochloride (“demeral hydrochloride”) (This has proved especially useful in the fenestration operation, since bleeding seems to me to be least troublesome with this method.) This type of anesthesia is used only when the services of a physician-anesthetist are available. It is not recommended for heavy patients.

If electrocoagulation is used for hemostasis (and this method is preferable), its use will influence the choice of anesthetic.

*Surgical Procedure*—The cutaneous incision is started anterior to the inferior border of the conchal cartilage (insert in fig 2A) and, following the concave contour of the conchal cartilage, is carried upward to the suprameatal triangle anterior to the margin of the helix (This forms the lower curve of the S, which is a reversed S [see insert in fig 2A] for the right ear.) It is continued upward, *hugging the margin of the helix* (forming the upper curve of the S). The extent to which the incision is carried upward depends on the exposure required. The exposure becomes progressively larger as the incision advances around the helix. (If the upper continuation of the incision between the helix and the tragus is advanced in a frontal direction instead of around the helix, the exposure will be cumbersome.) As the incision is started, it is carried first through skin, then through subcutaneous tissue and periosteum to bone. The helical portion of the incision must be superficial or the temporal muscle will be cut. The exposure is enhanced by cutting out a triangular piece of subcutaneous fibrous tissue (fig 2A) over the area above the superior wall of the external auditory canal, the apex of this piece of tissue being toward the zygoma. The periosteum is elevated over the mastoid and zygomatic areas, and retractors are inserted. The exposure obtained with this single incision (fig 2A) is now seen to be

practically the same as that obtained with the three incisions of Lempert (fig 1)

The opening up of the mastoid process with electrically driven burrs is performed in a manner described by Lempert<sup>51</sup> in his fenestration operation. It must be kept in mind that the lateral sinus, in these cases, is often far forward, and that caution must be exercised.

Diseased tissue and whatever cells are encountered in the mastoid process are cleaned out, and the epitympanic area is thoroughly exposed and cleaned, care being taken not to disturb the ossicles. If a cholesteatoma is present, *the matrix should be left in situ* (fig 2B).

The posterior and superior walls of the external auditory canal are lowered (fig 2C). As this is done, the membranous part of the canal is carefully separated from the bony part of the canal. The external attic wall (bridge, annulus tympanicus, sulcus tympanicus), or what remains of it, is removed (fig 2C).

The membranous portion of the canal now appears as a tube of skin. This "tube" is incised across its long axis, about 1/4 inch (6 mm) from its outer limit, thus leaving a "cuff" of tissue (fig 2D). The "cuff" is to be cut later and for the time being is retracted anteriorly.

The remaining or deep portion of the "tube" is incised and elevated according to the particular requirement (fig 2E). If the matrix of a cholesteatoma has been preserved, the incision and dissection of the flap is carried out so that it can be swung to the mastoid bowl lateral to the matrix (fig 2F). If there is no matrix of a cholesteatoma, the flap can be fashioned and separated so as to be swung up to the epitympanum and part of the antrum of the mastoid process.

Regardless of the way the flap is turned, I choose to carry the opposing incision through the perforation, so that there is no longer a hole in this tongue-shaped flap where it attaches to the unperforated portion of the tympanic membrane.

Now I return to the "cuff" of skin previously mentioned. It is severed either anteriorly, so that it can be reflected back to the mastoid bowl, or posteriorly, so that it can be thrown upward toward the roof (fig 2G) of the new meatomastoid cavity. I prefer to throw it upward, since in this position the flap seems to cut down the granulation tissue that often forms just within the new meatal opening at its superior portion.

The flaps are held in place with "paressine lace-mesh surgical dressing." The incision separating the tragus from the helix is packed with gauze saturated with a 5 per cent sulfathiazole sodium solution, or with plain petrolatum USP if no cutaneous sutures are used. At times I choose to suture the skin around the helix if it appears that this partial

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51 Lempert (footnotes 10e and 49)

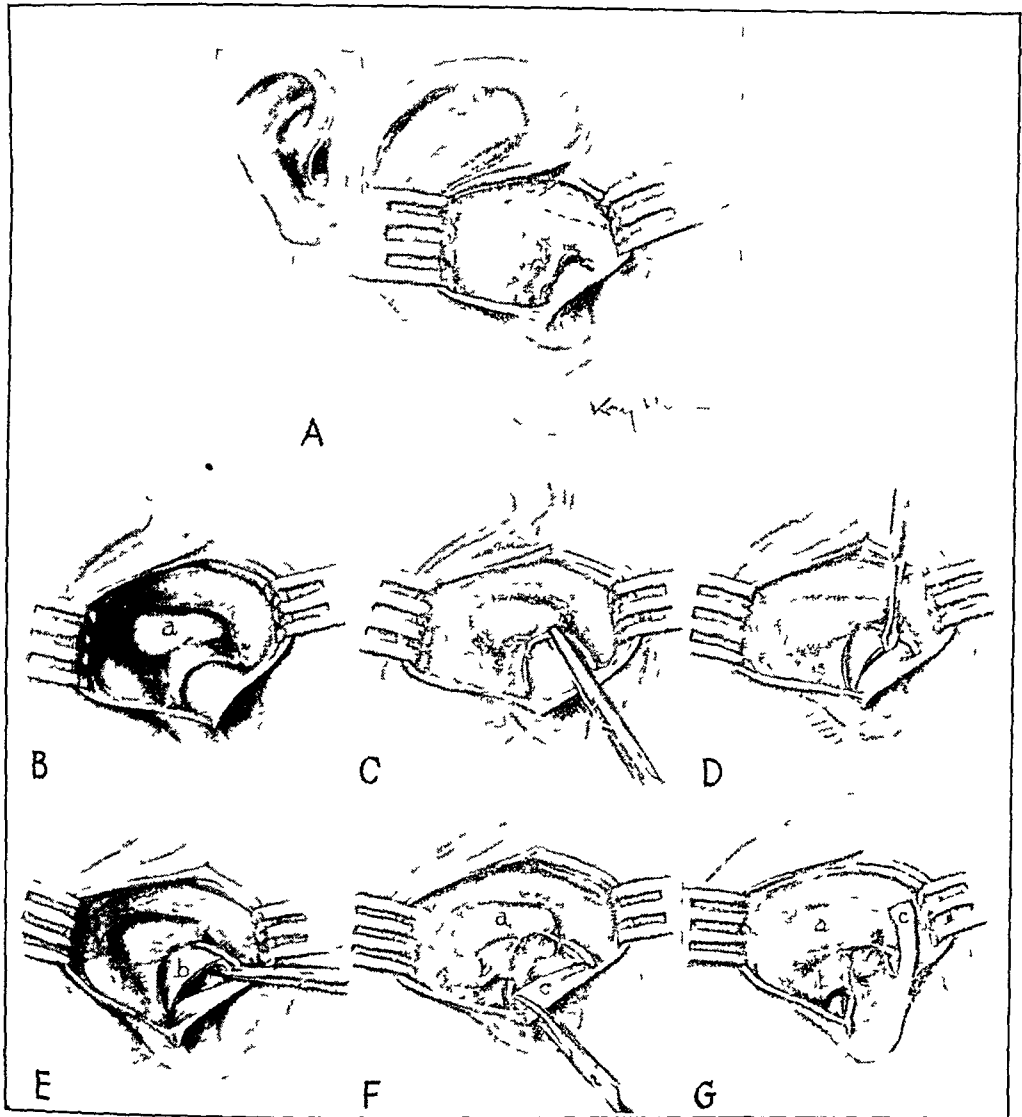


Fig 2—A, single incision (insert), which, for the right ear tends to take the curves of a reversed S. The larger drawing shows the exposure obtained with retraction after the periosteum has been elevated and a triangular portion of subcutaneous fibrous tissue has been removed above the superior portion of the external auditory canal.

B, everted cavity of the mastoid process. The cholesteatoma has been removed except for the matrix (a), which was left in situ. The dimple at the lower margin of the matrix leads to the posterosuperior perforation of the tympanic membrane (pars flaccida).

C, removal of the posterior and superoposterior bony walls of the external auditory canal. The external attic wall (bridge, annulus tympanicus, sulcus tympanicus) is being removed.

D, incision being made in the lateral portion of the membranous external auditory canal producing an external "cuff" of skin.

E, "cuff" being retracted aside. A flap is made from the inner portion of the skin tube (b). The anterior incision is carried to and through the anterior margin of the perforation of the pars flaccida and eliminates the perforation.

F, flap (b) is swung lateral to the matrix (a) of the cholesteatoma into the mastoid bowl. The "cuff" (c) is now severed posteriorly. (It can be cut anteriorly if one so chooses).

G, flaps in place, where they are held by pressure gauze.

closure will not impede the postoperative care or produce too small a meatus when healing occurs

*Postoperative Care* —The patient is allowed to be out of bed on the first or the second postoperative day. The packing and the "paressine" dressing are removed on the fifth or the sixth postoperative day. If no sutures are used, a small piece of petrolatum-impregnated gauze is replaced in the upper angle of the wound to prevent the wound from closing. At each dressing this petrolatum-treated gauze is replaced until it is seen that the desired opening will be maintained.

In the early stages the new cavity is not cleaned or touched in any way. The less the manipulating that is done, the better the healing seems to progress. Later, if the accumulated discharge is excessive, it is cleaned out as required, and granulations, if unruly, are controlled. In general, it is better to avoid the temptation of biting off or cauterizing the granulations, for, as the epithelium progressively lines the cavity, they seem to vanish.

Unless the thin fluid draining from the cavity is excessive, the large dressing can be removed at an early stage and cotton placed in the meatus and changed as often as it becomes saturated.

Penicillin, 25,000 units, is given intramuscularly every three hours for the first five postoperative days, occasionally longer.

#### COMMENT ON REPORT OF CASES

Only 10 cases in my series are reported, as the records of these are the only ones presently available. They do, however, represent cases done in succession and not cases chosen because of their successful end results.

The modified radical mastoidectomy was done in all of the 10 cases reported. In the first 7 it was done via the postauricular route, in the last 3, by the endaural route. (Since August 1945 I have used only the endaural technic in both the radical and the modified radical mastoidectomy.)

Cholesteatoma was present in 8 of the 10 cases. The matrix of each cholesteatoma was left in situ.

The hearing was improved 10 or more decibels for the frequencies 512, 1024 and 2048 cycles per second in 5 cases and 7 decibels in 2, it was decreased 5 decibels in 1 case. In 2 cases the hearing charts were not available when the records were reviewed.

The end result was a dry ear in every case. This was due in part to the excellent postoperative control maintained over the patients. The first 8 patients were Navy personnel, so that it was an easy matter to treat the patients as often and as long as desired. The same cooperation

# Report of Cases

Case	Age Sex Date	History	Location of Perforation	Date of Operation and Findings	Hearing			Course	End Result	
					Whispered Voice	Average Decibel Loss for Conventional Range	Preop			
1 G P S 1/C	22 M	Left ear discharging foul-smelling pus for 6 to 9 months, onset followed injury due to concussion blast roentgenogram sclerotic mastoid bone with possible cholesteatoma	Large posterosuperior perforation involving almost all of Shrapnell's membrane (pars flaccida, membrana flaccida)	8-24-44 Sclerotic mastoid bone with forward lateral sinus cholesteatoma from margins of perforation to antrum of mastoid process Operation Cholesteatoma matrix preserved postauricular incision meatal flap	Preop	Postop	38	31	Uneventful	Ear dry
2 G P L Y 2/C	35 M	Concussion injury of right ear in 1942 when his ship was torpedoed mucoid type of matter not foul draining from ear roentgenogram diffusely sclerotic mastoid bone	Posterosuperior marginal perforation involving the pars flaccida and extending into the pars tensa, with granulation present	3-28-45 Sclerotic mastoid bone stringy mucopus in antrum of mastoid process extending further to a mucous membrane-lined cavity posterior to the canal wall perforation of the posterior bony canal wall near the membrana tympani Operation Postauricular incision, meatal flap	0/15	5/15	60	31	Uneventful	Ear dry
3 D I P A E M 1/C	22 M	Concussion injury of left ear due to blast of 90 mm gun 9(?) months before admission foul smelling purulent matter draining from ear roentgenogram sclerotic mastoid bone	Anterosuperior perforation of membrana flaccida	3-29-45 Sclerotic mastoid bone cholesteatoma in attic extending into antrum Operation cholesteatoma matrix preserved postauricular incision, meatal flap					Uneventful	Ear dry
4 I T J S S 2/C	17 M	Foul-smelling pus draining from left ear for 10 months roentgenogram sclerotic mastoid bone	Anterosuperior perforation of pars flaccida and posterosuperior perforation of pars tensa, with drum retracted to promontory	4-11-45 Sclerotic mastoid bone cholesteatoma extending from anterosuperior perforation to epitympanum and antrum of mastoid process Operation Matrix of cholesteatoma preserved postauricular incision, meatal flap	13/15	15/15	16	3	Uneventful	Ear dry



*Report of Cases—Continued*

Case	Age Sex	History	Location of Perforation	Date of Operation and Findings	Hearing			Course	End Result
					Whispered Voice	Average Decibel Loss for Conversational Range			
					Preop	Postop	Preop	Postop	
5 K A N EM 3/C	27 M	Pus draining from ears intermittently since childhood, pus draining from right ear since 1942 simple mastoidectomy done in 1943, but a foul smelling pus continued to drain, roentgenogram defect from previous mastoidectomy	Posterosuperior marginal perforation anterior border of perforation retracted to promontory, granulations seen through perforations	6-21-45 Granulations present in area above perforation and antrum of mastoid process Operation What remained of incus was removed postauricular incision, meatal flap					Ear dry
6 C K M S 1/C	38 M	Pus running from left ear since 1943, onset followed exposure to firing of 5 inch gun, discharge foul smelling, "pressure" pains in left side of head, dizzy spells Roentgenogram sclerotic mastoid bone	Anterosuperior perforation of pars flaccida granulation tissue present	7-11-45 Dural plate low and lateral sinus far forward cholesteatoma running from margins of perforation through attic to antrum Operation Matrix of cholesteatoma preserved, postauricular incision meatal flap	0/15	0/15	88	93	Ear dry
7 J J S SM 2/C	25 M	Pus draining intermittently from left ear since childhood recurrence of drainage following bomb concussion in 1943 drainage was intermittent but became continuous after swimming in 1944, discharge foul smelling	Large marginal perforation of posterosuperior quadrant	8-2-45 Sclerotic mastoid bone cholesteatoma extending from margins of perforation through attic to antrum Operation Matrix of cholesteatoma preserved, postauricular incision meatal flap	2/15	6/15	42	26	Ear dry
8 H H C GM 3/C	25 M	Pus running from left ear at 14, which cleared up, recurrence of drainage during past year, since sea duty, discharge foul smelling, roentgenogram sclerotic mastoid bone and mastoiditis	Large anterosuperior marginal perforation of pars flaccida	8 6 45 Sclerotic mastoid bone, dural plate and lateral sinus hugged the canal so that the antrum was approached through the canal cholesteatoma extending from margin of perforation through attic to antrum Operation Matrix of cholesteatoma preserved endaural technique Lempert incision	1/15	10/15	68	28	Ear dry

Case	Age Sex	History	Location of Perforation	Date of Operation and Findings	Hearing				Course	End Result
					Whispered Voice		Average Decibel Loss for Conversational Range			
					Preop	Postop	Preop	Postop		
9 Mrs E G	57 F	Pus running from right ear "many years", aural polyps removed in 1936 spontaneous bleeding in 1941, contents of canal reported as blood clot and cholesteatomatous debris Ear and right side of head started to pain in Sept 1945 seen in Jan 1946 foul-smelling discharge and deep pain in ear roentgenogram sclerotic mastoid bone with cholesteatoma	All of pars flaccida gone and posterior 1/3 of pars tensa anterior part of perforation of pars tensa bound down to promontory	2-4-46 Sclerotic mastoid bone with cholesteatoma extending from margins of perforation to antrum of mastoid process incus presumed to be gone Operation Matrix of cholesteatoma preserved endaural technic Lempert incision	48		38		Uneventful	Ear dry
10 L S	18 F	Foul-smelling pus draining intermittently from left ear for many years, onset of pain deep in ear in May 1946 transient vertigo roentgenogram sclerotic mastoid bone with cholesteatoma	All of pars flaccida gone pars tensa intact contour of malleus covered with cholesteatoma matrix seen through perforation	6 18-46 Sclerotic mastoid bone with cholesteatoma extending from margin of perforation to antrum of mastoid process Operation Matrix cholesteatoma preserved endaural technic modified Lempert incision	20		13		Uneventful	Ear dry

was obtained from the 2 civilian patients (Conscientious postoperative observation and treatment are almost as important as exacting operative technic )

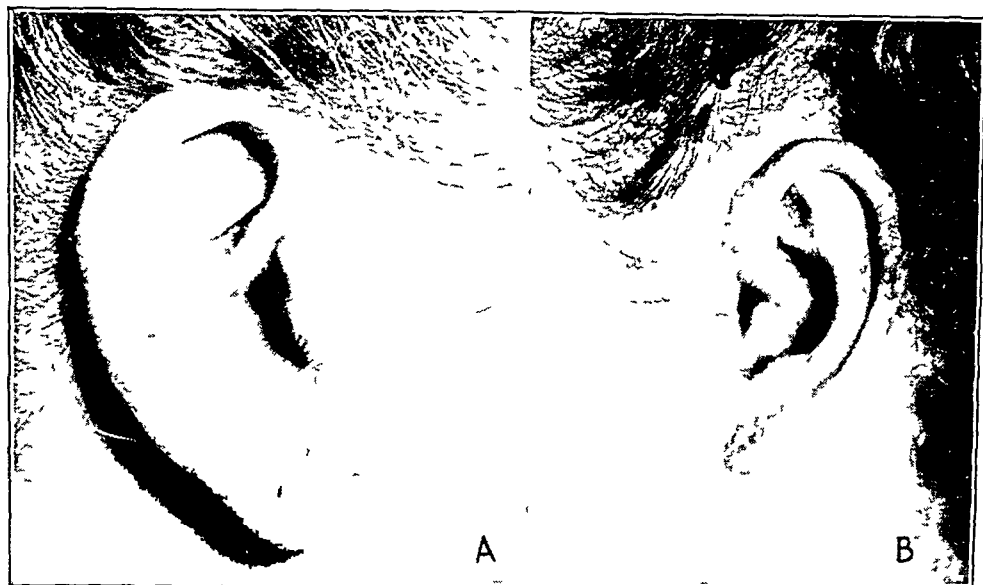


Fig 3—*A*, appearance of an ear on which the modified radical mastoidectomy was done, with use of the endaural technic and Lempert's incisions (case 9, table)

*B*, appearance of an ear on which the modified radical mastoidectomy was done with the endaural technic, a single incision being used and flaps made according to the technic described in figure 2 (case 10, table)

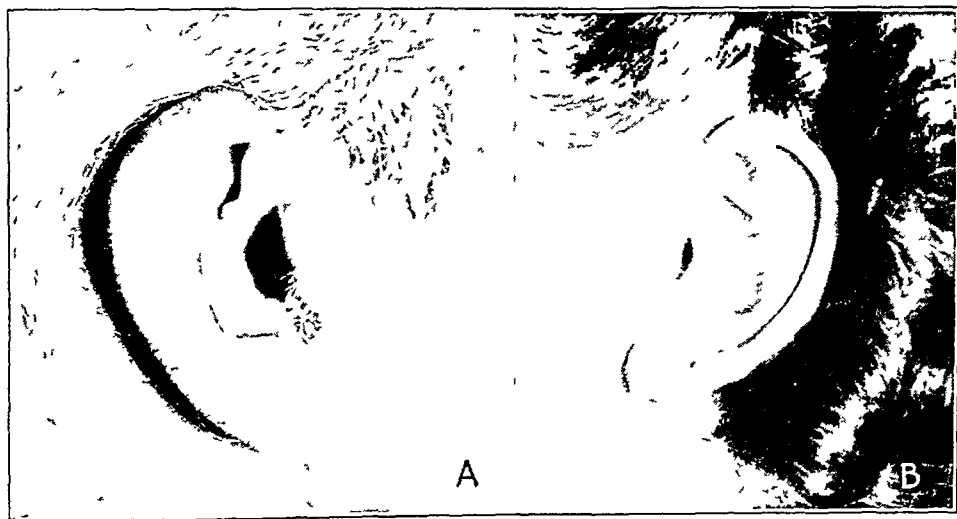


Fig 4—*A*, appearance of an ear on which the fenestration operation was performed with the endaural technic, a single incision and a 'cuff' flap being used according to the technic illustrated in figure 2

*B*, appearance of an ear on which the fenestration operation was done with the endaural technic, a single incision and a 'cuff' flap being used

The modified Lempert incision was used only in 1 of these 10 cases (no 10), but it has been tested in cases not ready for this report in which the modified radical mastoidectomy was performed and in cases in which fenestration was done for otosclerosis (fig 4)

In the period of time elapsed between the surgical operation done in case 1 and that done in case 10, there was only 1 intervening patient (after the eighth successive modified radical mastoidectomy) on whom a radical mastoidectomy was performed. This makes the ratio of modified radical to radical operations 10 to 1 in this small series. While this might not represent an accurate cross section if a large series were reported, it does suggest that the modified radical mastoidectomy has a wider field of usefulness than it is generally allowed.

In 3 of the patients the ears had been discharging for less than a year, yet the mastoid bones of each were sclerotic, as were the mastoid bones of the remaining patients. These examples favor Wittmaack's theory that in such cases pneumatization<sup>52</sup> was interfered with by otitis neonatorum, and, as stated by Almour,<sup>11a</sup> the patients were ready candidates for chronic otorrhea once acute otitis media had set in.

When the matrix of the chloesteatoma is left in situ, it is not possible to determine the exact status of the ossicles. This is not important as the matrix has sealed off the ossicles, or what remains of them, and the middle ear from infection.

These results would appear to refute Lathrop's<sup>41</sup> contention that removal of the incus and amputation of the head of the malleus are important in the performance of an adequate modified radical mastoidectomy.

The results also contradict the statement that in patients on whom the modified radical mastoidectomy has been done the incidence of dry ears is small.<sup>48</sup>

#### SUMMARY

The modified radical mastoidectomy is the ideal operation in certain cases of chronic suppurative otitis media. It preserves the hearing better than the radical mastoidectomy. The modified radical mastoidectomy should supplant the radical operation more often than it does. A dry ear can be obtained as often (or more often) with the modified radical operation as with the radical operation.

In most cases the matrix of the cholesteatoma should be preserved.

The removal of the external attic wall (annulus tympanicus, sulcus tympanicus, bridge) is an important step in the technic.

<sup>52</sup> Cheattle, H. The Etiology and Prevention of Chronic Suppurative Otitis Media, *Acta oto laryng* 5 283-294, 1923, International Survey of Ophthalmology, Otology and Rhinology, December 1923, p 143, cited by Page 1. Pierce, N. H., in discussion on Page 1.

Ten cases are reported in which the modified radical mastoidectomy was performed. Though in the majority of these cases the operation was performed through the postauricular route, it is felt that Lempert's endaural antauricular approach is preferable.

A single endaural incision and a method of utilizing the skin of the external auditory canal are described. This skin-saving procedure may reduce the healing time.

516 Sutter Street

## THE INFRATEMPORAL FOSSA AND MASTICATOR SPACES

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AT FIRST glance the title of this article would suggest that the subject is in the field of the dental and oral surgeon rather than in that of the otolaryngologist. This is true, but, if I may judge from my observations in Army and civilian practice, the otolaryngologist will see directly or in consultation enough pathologic conditions in these regions to create a desire for a more detailed knowledge of the areas than just a casual one. Without doubt, pathologic changes in these regions will in the majority of cases be of dental origin but may arise in some cases from the maxillary sinus, the middle ear or even the pharynx, indirectly, e g, from septic thrombophlebitis. The area is often involved in the event of trauma to the upper or lower jaw.

The subject will be developed and presented under three headings. First will be mentioned the type of cases, creating interest in the subjects, that came under my observation. Next, a review of the anatomy will be presented, with the aid of photographs of actual dissections, models and diagrams copied from other articles. Third, comments will be made on the handling and treatment of the cases.

### TYPE OF CASES

In all patients presenting themselves with pathologic changes in the masticator and infratemporal spaces there was invariably a complaint of spasm of the muscles of the jaw (trismus). Pain, external swelling and/or elevation of temperature may or may not have been present but trismus was. Probably the commonest cause of pathologic changes in these spaces or regions is infection secondary to the preparation for and actual manipulation of the lower molar teeth and adjacent areas. It is a controversial question as to what part in causing infection is played by the introduction of the anesthetic needle for the blockage of the dental and buccal nerves. In some cases this may be the responsible factor but admittedly such instances must be rare. The erosion of the bone of the

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Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society.

mandible, secondary to dental abscess, will permit the entrance of infection into the masticator spaces Tschiasny<sup>1</sup> made the observation that if the abscess erodes bone below the mylohyoid ridges of the mandible infection may pass into the neck, and if the erosion occurs above the mylohyoid ridge the floor of the mouth and the masticator spaces will be involved

Infection of the masticator spaces is not uncommon in cases of trauma of the face In such injuries compound fractures of the maxilla and mandible occur, and infection gains entrance from the oral cavity into the masticator spaces This occurrence is particularly likely if a tooth is present in the line of the fracture Fractures of the mandible result in infection in the masticator spaces more often than do those of the maxilla During the last war it was not uncommon for one to see foreign bodies, such as shrapnel, in the infratemporal fossa, the fragments having penetrated the soft tissues laterally or actually having passed through the walls of the maxillary sinus to gain entrance into the infratemporal fossa Infection was usually absent, this fact no doubt the result of the early and adequate use of antibiotic and chemotherapeutic agents

Theoretically, infection in the maxillary sinus may indirectly or directly be responsible for infection in the infratemporal fossa or masticator spaces The posterior wall of the sinus is extremely thin Woodward,<sup>2</sup> prior to this day of antibiotics and chemotherapy, reported the case of a child who died of meningitis which was secondary to suppurative maxillary sinusitis Extension occurred from the sinus, and thrombophlebitis developed in the infratemporal and pterygomaxillary fossae I have never seen this occur but have seen a carcinoma of the antrum extend into the infratemporal fossa, infiltrating the pterygoid muscles and causing trismus prior to any external swelling Trismus was the presenting and chief complaint

Another cause of trismus, which is of particular interest to the otolaryngologist but does not involve the masticator space, strictly speaking, is extension of infection from the middle ear to the posterior part of the mandibular fossa It has been suggested by Lillie and Simonton<sup>3</sup> and Grant<sup>4</sup> that infection passes through the petrotympanic (glaserian)

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1 Tschiasny, K Ludwig's Angina, *Arch Otolaryng* **38** 485-496 (Nov) 1943

2 Woodward, F D Personal communication to the author

3 Lillie, H I, and Simonton, K M Abscess of the Mandibular Fossa Secondary to Otitis Media, *Arch Otolaryng* **34** 485-492 (Sept) 1941

4 Grant C C Abscess of the Pterygomaxillary Fossa Complicating Otitic Infections Review of the Literature and Report of a Case, *Arch Otolaryng* **16** 845-850 (Dec) 1932

fissure Infection is believed also to spread by way of the lymphatic and venous plexuses

The types of cases mentioned are common enough to have been seen by many otolaryngologists and to serve as the basis for a more than casual interest in the anatomy, to be presented

#### ANATOMY

In the presentation of the anatomy, one must consider four spaces or fossae The first, and principal, one is the infratemporal (subtemporal) fossa, which is bounded laterally by the zygomatic arch and the ramus of the mandible, anteriorly by the zygomatic process of the max-

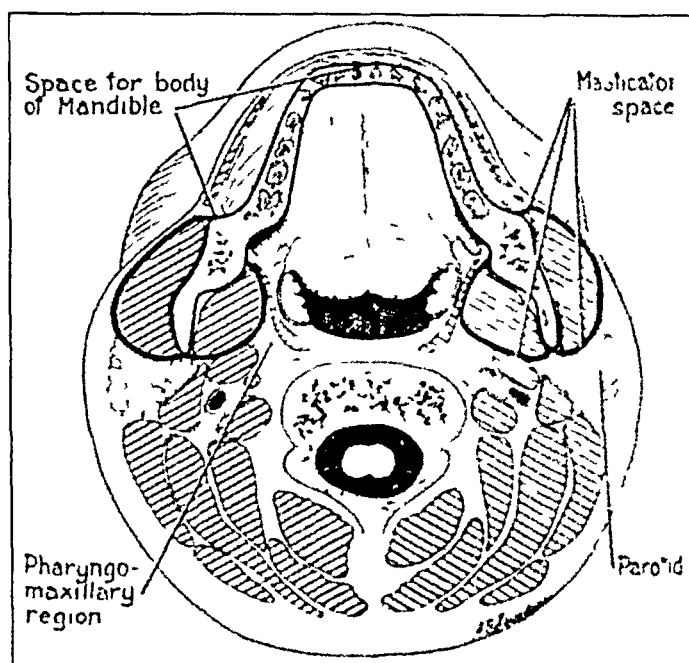


Fig 1—Diagrammatic cross section (Hall and Morris<sup>3</sup>) The heavy lines bound the masticator space The space for the body of the mandible is shown as being continuous subperiosteally with the masticator space Note that the internal pterygoid muscle, which is the medial boundary of the pharyngomaxillary space, is contained within the masticator space The pharyngomaxillary and the masticator spaces are not connected The parotid gland lies outside the masticator space It is easily seen how medial extension causes intraoral signs and lateral extension causes external signs

illa, medially by the lateral pterygoid plate of the sphenoid bone and above by the greater wing of the sphenoid bone This fossa is located below the temporal fossa and contains in part the temporal muscle, the pterygoid muscles, the internal maxillary artery and the lingual and dental nerves The next space, or potential space is that between the mandible and its periosteum and muscle attachments (fig 1, from Hall



and Morris<sup>5</sup>) Next is the pterygopalatine (pterygomaxillary) fossa, which is a small cleft situated between the rounded posterior border of the maxilla and the descending pterygoid process of the sphenoid bone and contains the maxillary artery and nerve and the sphenopalatine ganglion The fourth space is a part of the mandibular fossa, posterior to the articular cartilages and anterior to the middle ear and external auditory canal, and contains an extension of the parotid gland

Mainland<sup>6</sup> stated, "Cervical deep fascia is so complicated, so variable and so much affected by technique that descriptions vary greatly" The same statement may apply to the fascia of the head and face, for the structures of these parts are enveloped in fascia that is nothing more than an extension upward of that of the cervical region Of interest here is the deep fascia only, which is divided into a superficial and a deep layer The superficial layer is that noted externally on dissection, and the deep layer is that part of the fascia projecting inward from the superficial structures

Hall and Morris<sup>5</sup> made the observation that the body of the mandible anterior to the angle, and in the region of the lower molar teeth, rests in a sling formed by the internal (medial) pterygoid and masseter muscles This point is well demonstrated in the diagrams and photographs of the dissections Infection originating in the teeth or mandible and breaking through the periosteum will be limited to certain definite planes by the position of these muscles The infection may remain limited to the potential space within the periosteum of the mandible, and most often will be However, if there is a break in the periosteum, as in a fracture, then extension must be deep into the infratemporal fossa or upward beneath the zygomatic arch and the temporal muscle, in the event that the process begins on the lingual side of the mandible If lateral to the mandible, the extension may be limited by the periosteum, or, if a break through occurs, the infection may spread upward under the zygomatic arch and the temporal fascia superficial to the temporal muscle

Another anatomic point to be noted is that the internal (medial) pterygoid muscle acts as a firm barrier between the masticator spaces and the lateral pharyngeal (pharyngomaxillary) space (fig 1) From this point the subject will be elaborated on with the aid of the accompanying photographs of the actual dissections, models and diagrams

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5 Hall, C, and Morris, F Infections of the Masticator Space, *Ann Otol, Rhin & Laryng* 50 1123-1131 (Dec ) 1941

6 Mainland, D *Anatomy as a Basis for Medical and Dental Practice*, New York, Paul B Hoeber, Inc, 1945

## ILLUSTRATIVE PHOTOGRAPHS

FIGURE 2—Photograph *A*, of the initial dissection, shows the skin (1), superficial fascia (4) and platysma muscle (41) reflected from the area of interest. The parotid gland (2), with the duct extending forward to pass over the anterior border of the masseter muscle, is also reflected backward. Note that the parotid gland is enclosed in a layer of fascia separate from that of the masseter muscle. The gland is not a part of the masticator spaces. The retromandibular fossa is present at 3, showing the important element of the deep fascia of the neck reaching upward to become firmly attached to the angle and lower border of the mandible. From these points spring the fascia and periosteum covering the masseter muscle, mandible and internal pterygoid muscle. Thus, in part, the fascial floor of the infratemporal fossa and masticator spaces is formed. At 5 is the fascia covering the masseter muscle, extending upward from the inferior border



Fig 2—*A*, initial dissection, showing the skin, superficial fascia and platysma muscle reflected from the area of interest, *B*, a model, showing the branches of the facial nerve coursing along the surface of the masseter muscle and the temporal fascia

of the mandible to become attached to the zygomatic arch midway between 5 and 6. The muscle fibers are attached to the ramus of the mandible as it extends upward. The submaxillary gland is seen bulging downward below the mandible at 7, the facial artery is at 8 and the temporal artery at 9. Extending upward from the zygomatic arch to the temporal region is the dense temporal fascia (6). The branches of the facial nerve are not shown in the dissection, but in the photograph of the model (*B*) they course along the surface of the masseter muscle and the temporal fascia.

FIGURE 3—In this deeper dissection, the zygomatic arch has been severed at the junction of the zygoma (zygomatic process of the temporal bone) and the zygomatic bone. The arch has then been reflected backward, carrying with it the double layer of temporal fascia (1) and masseter muscle (4) and exposing the temporal muscle (2), with its insertion on the coronoid process and the ramus of the mandible (3). The potential space between the ramus of the mandible and the internal pterygoid muscle is demonstrated at 5. Fibers of the masseter

muscle attached to the lateral surface of the ramus of the mandible may be seen at 6. If this dissection is studied closely, two potential pathways for infection spreading upward may be seen. Infection beginning between the masseter muscle and the ramus of the mandible, say at 6, conceivably might spread upward to approach the under surface of the temporal fascia above the level of the zygomatic arch. But if the infection should be internal to the mandible, between it and the internal pterygoid muscle, at 5, then extension might be upward under the coronoid process and the temporal muscle, also causing tumefaction above the zygomatic arch, but in this event deep to the temporal muscle. Another route of extension in this area, about which more will be said, is inward between the two pterygoid muscles to the pterygopalatine (pterygomaxillary) fossa.

FIGURE 4—The dissection shown in this figure is deeper than that in figure 3. The ramus of the mandible has been removed to expose the contents of the infratemporal fossa. The coronoid process with the attachment of the temporal



Fig. 3—A deeper dissection, in which the zygomatic arch has been severed at the junction of the zygoma and the zygomatic bone.

muscle is illustrated at 1. The angle of the mandible is at 2. The pterygoid muscles are apparent, the external (lateral) at 3 and the internal (medial) at 4. Between the two, well illustrated, is a potential space which has been exposed by blunt dissection. This space leads toward the pterygopalatine (pterygomaxillary) fossa and may be an avenue for the extension of infection to that fossa.

FIGURE 5—These two photographs—A, of an actual dissection, and B, of a model—offer much for consideration. The temporal muscle and coronoid process, having been dissected free and reflected back, are shown at 1. The external (lateral) pterygoid muscle has been entirely removed. The lateral (muscular) pterygoid plate is shown at 2 in each photograph. This is a part of the medial boundary of the infratemporal fossa and the posterior boundary of the pterygopalatine fissure. Just above 2 the internal maxillary artery is seen.



Fig 4—A dissection deeper than that shown in figure 3, with the ramus of the mandible removed to expose the contents of the infratemporal fossa



Fig 5—A, actual dissection, the temporal muscle and coronoid process having been dissected free and reflected back, B, a model

crossing the pterygoid plate At 9, poorly shown, is the site of the foramen ovale The internal pterygoid muscle may be clearly seen at 3 At 8 is a potential space between the constrictor of the pharynx and the internal pterygoid muscle The internal pterygoid muscle acts as a barrier between the masticator space and the lateral pharyngeal region The thin posterior wall of the maxillary sinus is shown at 4, with an artificial burr opening just above 4 The thick fascia and periosteum have been separated from the bony wall and reflected backward (5) At 7 is an artificial opening into the oral cavity The intraoral mucous membrane and buccinator muscle have been dissected downward to make their communication at the site of upper molar teeth (not shown) The cross section of the malar extremity of the zygomatic arch is demonstrated at 6 The lingual and dental nerves are at 10

FIGURE 6—A longitudinal section of the head, just anterior to the angle of the mandible, illustrates the fascial sling, mentioned by Hall and Morris as containing the mandible and masticatory muscles This section also illustrates the potential planes, previously mentioned, between the muscles and the mandible The ramus of the mandible is at 2 The internal pterygoid muscle (3), external pterygoid muscle (4) and the masseter muscle (1) have been separated by blunt dissection (Figure 10, copied from Hall and Morris, shows a horizontal section more anterior than that of the dissection)

FIGURE 7—This dissection represents a section of the anatomy that may not be, strictly speaking, included in the subject as titled It belongs, rather, with the subject of extension of infection from the middle ear to the mandibular fossa by way of the petrotympanic (glaserian) fissure, previously written about by Lillie and Simonton I am under the impression that I have seen such a case in a child 7 years of age who had had a myringotomy for acute suppurative otitis media Forty-eight hours later, trismus, pain and swelling anterior to the ear and over the temporomandibular joint developed The patient was hospitalized and penicillin therapy instituted Favorable response was rapid, and drainage was not necessary In theory, the infection extends from the middle ear into the non-articular part of the mandibular fossa by way of the petrotympanic fissure The infection is subperiosteal and does not involve directly the articular portion of the temporomandibular joint The photograph does not offer much in the way of clarification of the point The external auditory canal (1) is visualized, with the space within the mandibular fossa which is occupied by an extension of the parotid gland The condyle of the mandible is shown at 4 Part of the capsule of the joint has been dissected and reflected upward and is represented at 2 The lower part of the joint cavity (meniscocondylar articulation) is shown at 3 The shaded area in the photograph, between the auditory canal and the condyle, is the area invaded by infection from the middle ear (subperiosteal)

FIGURE 8—This photograph on the side and base of the skull illustrates the mandibular fossa (1), with the petrotympanic fissure at 3 The auditory canal is at 2

#### TREATMENT AND SURGICAL APPROACH

The approach to pathologic conditions in the masticator space, infratemporal fossa and pterygopalatine fossa is not without difficulty One of three approaches may be chosen to reach the site of infection, the choice depending on the location of the area of fluctuation The first two mentioned are illustrated in figure 9 and figure 10, which are

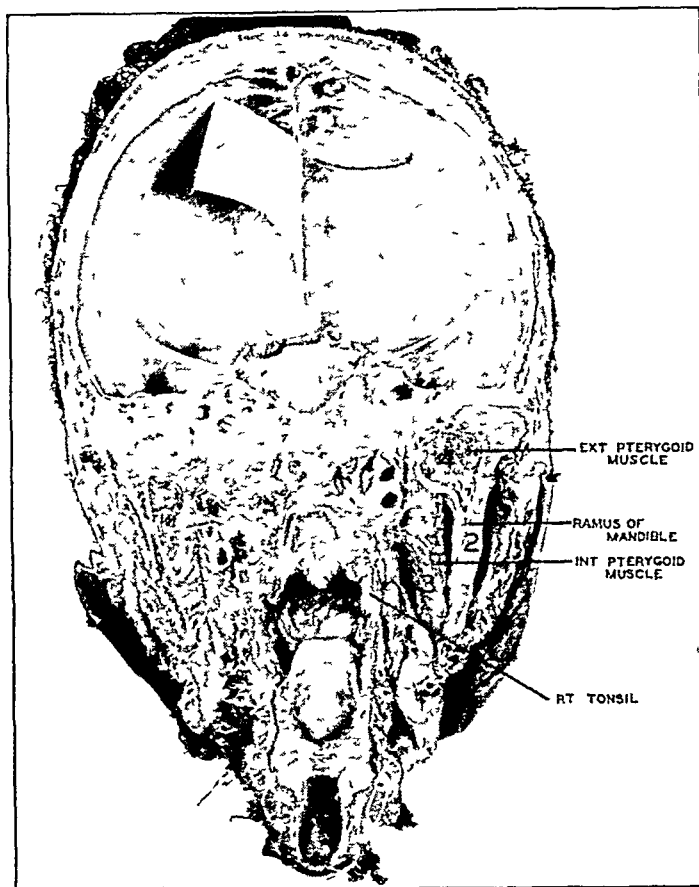


Fig 6—A longitudinal section of the head, just anterior to the angle of the mandible, illustrating the fascial sling



Fig 7—A dissection illustrating the extension of infection from the middle ear to the mandibular fossa by way of the petrotympanic (glaserian) fissure



Fig 8—A photograph of the side and base of the skull, showing the mandibular fossa, the petrotympanic fissure and the auditory canal

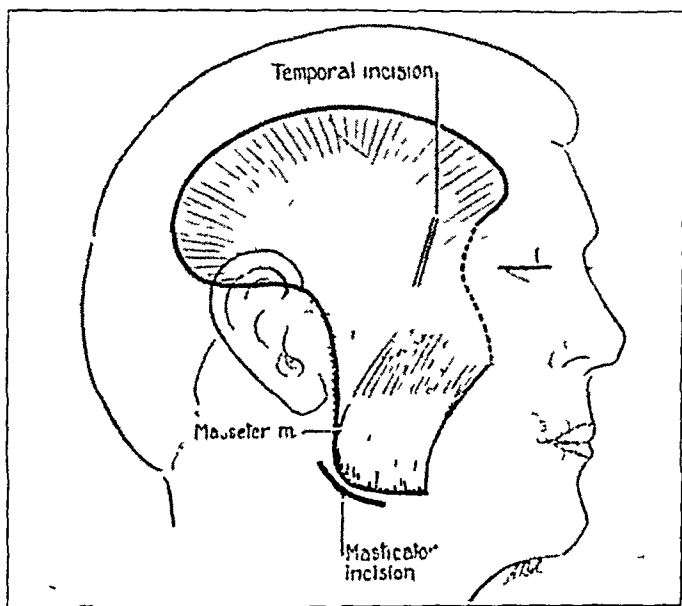


Fig 9—Lateral view, showing extent of the masticator space (Coller and Yglesias<sup>12</sup>) Heavy lines indicate the boundaries of the space The region containing the lower teeth and lying anterior to the masticator muscles is the space for the body of the mandible (Coller and Yglesias) The temporal and masticator incisions are shown (Hall and Morris<sup>5</sup>)

photographic copies of diagrams from the article by Hall and Morris<sup>5</sup> If the area of tumefaction and fluctuation is above the zygoma, whether superficial or deep to the temporal muscle, then a vertical incision above the zygoma is the approach of choice. The incision, if one desires, may be made nearer the root of the zygoma (more posterior than the diagram shows). By blunt dissection through the temporal muscle fibers, entrance into the infratemporal fossa and then into the pterygopalatine fossa may be gained.

Infection below the zygoma, medial or lateral to the ramus of the mandible, may be approached by an incision made horizontal to the inferior border of the mandible near the angle. By carrying this incision through the periosteum, if necessity requires doing so, one may, by up-

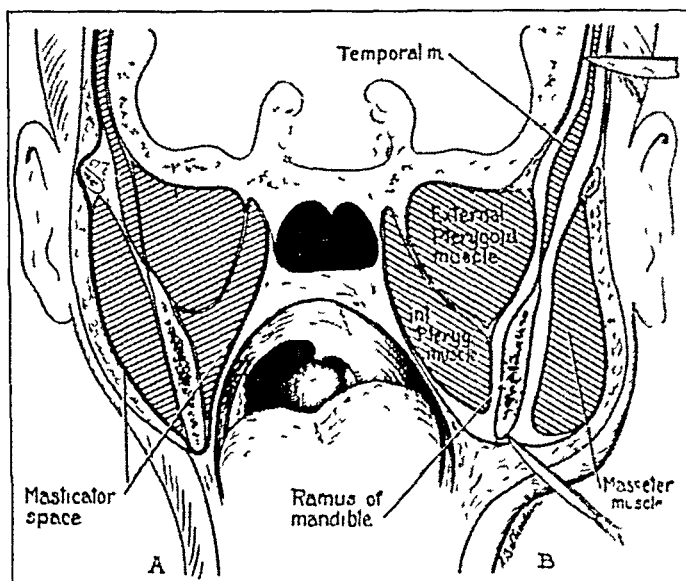


Fig 10—Diagrammatic frontal section (Hall and Morris<sup>5</sup>) Heavy lines represent the fascial sling, containing the masticatory muscles and the ramus A, normal side. The fascia is attached to the mandibular periosteum inferiorly, and the periosteum is firmly adherent to the mandible along its inferior aspect B, diseased side. Intraoral and external swellings both are shown and extension upward along the ramus into the temporal pouches is clearly seen. Scalpels indicate the extent of the masticator and of the temporal incisions.

ward blunt dissection, evacuate any purulent exudate medial to the masseter muscle or lateral to the internal pterygoid muscle, from which locality depending on the side of the mandible at which the upward dissection is made.

In such infections as those previously described in this paper, an aspirating needle and syringe are indispensable in locating purulent exudate. Once the exudate is found, blunt dissection may be utilized to secure adequate drainage.



The third method of approach to the infratemporal fossa, proved to be of value in the last war for the removal of shrapnel lodged in this area, is by the transantral route. This procedure is not difficult for the otolaryngologist who is familiar with the Caldwell-Luc technic. Sewall<sup>7</sup> described this procedure several years ago. I have used it on two occasions. The procedure depending on the type of case, the external carotid artery may have to be ligated, or preparations for ligation must be ready, because bleeding from the internal maxillary artery may cause trouble, and the external carotid artery is less difficult to ligate than the internal maxillary.

The intraoral approach is not usually satisfactory because of the location of the exudate and the trismus. If a fluctuant point appears intraorally, this should not be ignored. Incision should be made in the area.

The anesthetic of choice, if there is no danger of exudate or blood for example, gaining access to the larynx, is the intravenous type, e.g., thiopental sodium U.S.P. (sodium pentothal<sup>R</sup>). Inhalation of nitrous oxide or ether and local infiltration have been used at times but are not as effective and satisfactory as the intravenous method. Endotracheal anesthesia may be found useful in any procedure involving a transantral approach to the infratemporal fossa.

Confusion between infections of the masticator space and those of the parapharyngeal (pharyngomaxillary) space may occur. I have used the external approach to the parapharyngeal space without obtaining purulent exudate as expected, when later exploration of the infratemporal fossa lateral to the internal pterygoid muscle has resulted in the evacuation of the exudate present. The internal pterygoid muscle separates the infratemporal fossa and space from the parapharyngeal space. The commoner infections have been present subperiosteally, between the masseter muscle and the mandible. They have been secondary to extraction of the lower molars and secondary to fractures of the mandible. The incision horizontal to the inferior border of the mandible, near the angle, has been a satisfactory approach to them.

Drainage of the mandibular fossa should follow the technic advocated by Lillie and Simonton. A vertical incision is made anterior to and near the auditory meatus. The posterior part of the mandibular fossa is approached subperiosteally. The articular capsule is not entered.

Some word about the use of the antibiotics and chemotherapy is necessary. If antibiotics or sulfonamide drugs are given at the time of oral surgery or, say, shortly after a fracture of the mandible, of course the chances of the development of infection are lessened. Often, however, this

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7 Sewall, E. C. Surgical Removal of the Sphenopalatine Ganglion, *Ann Otol, Rhin & Laryng* 46: 79-86 (March) 1937.

type of infection is slow in development, and the initial trismus, discomfort and swelling are attributed to the reaction expected Swann,<sup>8</sup> in referring to dental disease as one of the most frequent sources of infections of the neck, stated, "Due to the fact that some external swelling frequently follows extractions, there is a tendency on the part of some men to ignore this very early sign of possible beginning deep infection" A week or ten days later infection is obvious Penicillin and/or sulfadiazine is started then, but in all likelihood incision and drainage will also be necessary It is wise for one to wait for fluctuation and not to attempt drainage too early in cases of infection of the masticator spaces It is wiser to start treatment with penicillin and/or sulfadiazine at the first suggestion of such complication

#### SUMMARY

Comments are made on the anatomy and pathologic conditions, principally infections, that may be encountered in or about the infratemporal fossa While the problem may not be primarily one of the otolaryngologist, it is in close proximity to his field, and his judgment and skill will often be involved directly in the handling of the problem

No claim is made to originality in the preparation of this paper In addition to publications previously mentioned, texts and articles by Morris,<sup>9</sup> Grant,<sup>10</sup> Shure<sup>11</sup> and Collier and Yglesias<sup>12</sup> have been useful Permission was obtained from Dr Colby Hall and the editor of the *Annals of Otolaryngology and Rhinology* to use figures 1, 9 and 10

Dr W Roy Mason, Jr, assistant professor of anatomy, Department of Medicine, University of Virginia, aided in obtaining material for this paper

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8 Swann, C C Deep Infections of the Neck, with Particular Reference to the Role of Dental Foci, *Ann Otol, Rhin & Laryng* 55 29-43 (March) 1946

9 Morris, H Morris's Human Anatomy A Complete Systematic Treatise by English and American Authors, ed 8, edited by C M Jackson, Philadelphia, P Blakiston's Son & Co, 1925

10 Grant, J C B Method of Anatomy Descriptive and Deductive, Baltimore, William Wood & Company, 1937, An Atlas of Anatomy, *ibid*, 1943

11 Shure, I I Abscess of the Pterygomaxillary Space with Involvement of the Mandibular Fossa Review of the Literature and Report of a Case, *Arch Otolaryng* 38 230-235 (Sept) 1943

12 Collier, F A and Yglesias, L Infections of the Lip and Face, *Surg, Gynec & Obst* 60 277-289 (Feb, no 2A) 1935

## BLAST PERFORATION OF THE EAR DRUM

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THIS series involves 87 blast-damaged ear drums, most of which were seen less than seventy-two hours after injury. In none of the cases was there any evidence of thermal or chemical burn. There was no gross contamination with gasoline, oil, water or dirt. The incidents occurred over a period of four months, so that they constituted a running series rather than an overwhelming load of patients all at one time. The causative weapon was primarily the German V-1 flying bomb, with 12 injuries from breech explosions of 90 mm guns, 2 from V-2 rocket bomb, 1 from artillery and 1 from a teller mine. Essentially the causative factor in each case was an uncomplicated severe compression wave.

The opportunity is rarely presented for one observer to see an appreciable number of blast-damaged ear drums soon after their injury, and particularly to follow them for any period of time.<sup>1</sup> The customary chain of evacuations for wartime casualties involved transferring the patient through various medical units as rapidly as his condition would permit, so that no one otologist was able to observe an injury early and to follow it for any appreciable time. Under these conditions tympanic damage received attention secondary to that of other wounds and often cursory in nature, at least until the patient reached a rear general hospital, usually several weeks later. If treatment was instituted earlier, observations by several otologists were involved and hence were of less value than observations made by a single otologist, covering the whole time.

This type of injury is not infrequently observed in civilians, in whom it is produced by the same physical factor, namely, sudden increase or decrease of air pressure. A slap on the ear, striking water on the side in diving,<sup>2</sup> and blast from an air hose inadvertently directed into the ear

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1 (a) Silcox, L. E., and Schenck, H. P. Blast Injury of the Ears, *Arch Otolaryng* 39 413-420 (May) 1944. (b) Colledge, L. Injuries to the Ear in Modern Warfare, *J. Laryng & Otol* 36 283-287 (June) 1921.

2 Sprenger, W. Sport Injuries in the Region of the Ear, *Wien klin Wchnschr* 54 316-317 (April) 1941. McCartney, C. Minor Injuries in Recreation, *J. Roy. Nav. Med. Serv.* 26 139-143 (April) 1940.

are a few examples of the many, and sometimes bizarre,<sup>3</sup> ways in which identical injuries are daily produced. Immediate medical advice should be sought, as adequate care may contribute to early healing.

## OBSERVATIONS

*Severity of Damage*—It early became apparent that some system had to be evolved for recording the extent of damage, since the likelihood of complete healing, as well as the time required for such healing seemed to be definitely related to the severity of the damage. A survey of the literature failed to show any such system, so the following simple criteria were used. Two factors were taken into consideration: (1) size of perforation (or area of damage) and (2) extent of ecchymosis. For purposes of this series size of perforation is computed by multiplying the estimated short diameter in millimeters by the estimated long diameter in millimeters, thus arriving at a rough approximation of the area of the drum missing.

TABLE 1—*Classification of the Cases of the Series*

Category	Damage	Cases
A	Slight	30
B	Moderate	33
C	Severe	8
D	Very severe	16

On this basis, without ecchymosis, an area of 8 or less was considered slight area damage, 9 to 30 as moderate area damage, 31 to 43 severe area damage and 48 or over very severe area damage.

Ecchymosis is a more difficult factor for which to lay down criteria but is of such importance that a careful effort was made to estimate the extent in each case, using the terms "slight", "moderate" and "severe". When moderate or severe ecchymosis was present in a drum, the area figure of which was in the upper third of a given category, the injury was placed in the next most severe category. For example:

Area damage 46, ecchymosis severe=very severe damage

Area damage 7, ecchymosis moderate=moderate damage

The cases of this series fell into the categories shown in table 1.

*Physical Factors*—An attempt was made to assess the degree to which each of several physical factors influenced the production of the perforations. Each patient was carefully questioned with regard to the type of explosion, the distance from him, screening (i.e., intervening building or sizable object) and protective devices worn or protective practices carried out.

3 Milovanovic, M. Lightning Stroke as Cause of Rupture of Tympanic Membrane, *Monatschr f Ohrenh* 69:489-492 (April) 1935.

Table 2 correlates the type of explosion involved, the distance away and the severity of the damage. It is seen that most of the drums severely damaged by V-1 bombs were at a distance of between 20 and 60 feet (6 and 18 meters), though severe damage can occur at more than 80 feet (24 meters). The estimates of distance are those made by the patients, subject to all of the obvious psychologic factors. Those whose estimates ran below 20 feet (one estimate was as low as 10 feet [3 meters]) were severely questioned in detail but nevertheless these

TABLE 2—*Correlation of Type of Explosion Involved, Distance Away and Severity of Damage*

Type of Explosion	Distance in Feet	Category of Damage				Total
		A	B	C	D	
German V-1 (flying bomb)	Less than 20	3	1	—	—	4
	21-30	4	3	1	4	12
	31-40	1	1	1	3	6
	41-50	3	1	—	1	5
	51-60	4	4	4	3	15
	61-70	5	3	1	1	10
	71-80	2	2	—	1	5
	More than 80	3	7	—	1	11
Teller mine	Under jeep	—	1	—	—	1
Breech explosion of 91 mm gun	Less than 4	2	5	1	1	9
	More than 4	—	3	—	—	3
German V-2 (rocket bomb)	150	1	—	—	—	1
81 mm mortar	3	—	—	—	1	1
Total		28	31	8	16	83*
*Details were unobtainable in 4 cases						

estimates were stoutly maintained. It would seem unlikely that any sort of protection would avail to save a life at 10 feet from an explosion of 2,000 pounds (900 Kg) of trinitrotoluene.

*Screening*—Sixty-six of the ear drums were perforated while the patients were in the open with no screening. Table 3 shows details for those that were screened. It is seen that even a prone position in a pit or behind a sandbag wall did not prevent severe damage in 3 drums from near misses by V-1's. The interior of a light frame building offers good protection from this particular type of injury.

*Protection*—No patient was wearing any type of specific protective device in the ears, i e, cotton, ear plugs, etc. Not one placed hands over the ears or fingers in the ears, though most were alert to the approach and imminent explosion of the bomb. Two patients were wearing ear phones (similar to a stethoscope), and both were injured by breech explosion of a 90 mm gun at less than 4 feet (about 1 meter). One suffered mild damage (2 by 3 mm, no ecchymosis) in one ear only.

TABLE 3—*Effect of Screening*

Explosion	Screening	Position	Distance in Feet		Damage	
					R	L
V-1	Six foot pit	Prone	40	R—mod	L—severe	
V-1	Bomb behind truck patient in cab	Sitting	30	R—mod	L—slight	
V-1	Eight foot sandbag wall	Erect	90	R—mod	L—very sev	
Teller mine	Patient sitting in jeep	Sitting	3	R—mod	L—none	
V-1	Four foot pit	Prone	30	R—very sev	L—none	
V-1	Four foot pit	Prone	35	R—sev	L—none	
V-1	Truck between patient and bomb	Erect	30	R—none	L—mod	
V-1	Heavy trailer between patient and bomb	Erect	25	R—slight	L—severe	
V-1	Truck between patient and bomb	Erect	30	R—mod	L—mod	
V-1	Sandbag wall	Erect	10	R—slight	L—mod	
V-1	Brick wall	Erect	90	R—none	L—slight	
V-1	Patient inside light frame building	Erect	70	R—slight	L—none	
V-1	bomb 20 ft from building	Erect	70	R—slight	L—slight	
V-1	bomb 20 ft from building	Erect	60	R—slight	L—mod	
V-1	bomb 20 ft from building	Erect	60	R—slight	L—none	
V-1	bomb 20 ft from building	Erect	60	R—none	L—mod	
V-1	bomb 20 ft from building	Erect	80	R—slight	L—none	

TABLE 4—*Effect of Cerumen*

Case	Distance in Feet	Explosion and Screening	Position	Cerumen	Damage
B H	30	V-1 Truck between patient and bomb	Erect	R—complete occlusion	None
				L—no cerumen	B
A M	75	V-1 No screening	Prone	R—complete occlusion	A
				L—complete occlusion	None
M P	25	V-1 Heavy trailer between patient and bomb	Erect	R—80% occlusion	A
				L—no cerumen	D
H S	35	V-1 No screening	Erect	R—complete occlusion	None
				L—no cerumen	D
A T	10 (?)	V-1 Sandbag wall	Erect	R—60% occlusion	A
				L—no cerumen	B

The other patient habitually kept one ear piece slightly out of his right ear to enable him to hear local orders. He suffered a double perforation in the right ear (2 by 2 mm and 3 by 3 mm, ecchymosis mild), while the left ear escaped uninjured. It is not known on which side of the patients the explosions occurred.

*Cerumen*—It has been reported that an accumulation of cerumen in the external canal will protect ears from blast damage. Only 5 such cases were encountered. Table 4 records the pertinent facts about

these, and it appears, as might be expected, that cerumen offers real protection. The fact that it was not present in the remaining 82 cases speaks in a vague, negative sort of way for the protection it offers.

It is realized that the data concerning physical factors would be much more pertinent if they could be extended to cover the number and the situation of persons in the same incident, exposed to the same trauma, who sustained no injury. However, time and the situation did not permit such an intensive study of the numerous incidents involved.

*Hearing*—Whispered voice and tuning forks were the only means of testing available. Since they give only gross estimates of hearing loss, the results are of value only on that basis. Generally speaking, when a patient was seen soon after injury there was a marked loss of hearing at the first examination. The hearing returned to near normal over a period of two to four weeks. Tests were done with a variety of words that could not be memorized, and sibilants were avoided.

Average hearing first visit—6 5/15

Average hearing last visit—13 5/15

Such gross results shed little light on the question of whether hearing defects resulting from blast are conductive system or nerve type, but they do demonstrate that the loss is temporary in the majority of instances. Since a goodly number of patients were engaged in active operation of antiaircraft artillery, there may be presumed to have been a substantial percentage with preexisting nerve loss due to trauma of heavy firing, and accurate tests would have been of limited value.

*Treatment*—It is well established that most uncontaminated small perforations will heal without any assistance.<sup>4</sup> The healing process, however, often requires a prolonged period of time to fill in a defect of any size.<sup>5</sup> A soldier, when returned to duty in a theater of operations, may be called on to expose himself to the elements and to further aural trauma. There is a natural reluctance to return the patient to such conditions without protection for the middle ear, since water will cause irritation or outright infection if introduced into the middle ear. With these considerations in mind it was felt that the earliest application of a patch would be the treatment of choice.

The procedure of patching a perforation of the ear drum has been reported previously by many authors, and technics and criteria

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4 (a) Ireland, P. E. Traumatic Perforations of Tympanic Membrane Due to Blast Injuries, *Canad. M. A. J.* 54: 256-258 (March) 1946. (b) Collins, E. G. Injury to the Ears Among Battle Casualties, *J. Laryng. & Otol.* 59: 1-15 (Jan.) 1944. Silcox and Schenck.<sup>1a</sup>

5 Chavanne, F. Rupture of the Tympanum from Shell Explosions, *Laryngoscope* 30: 441 (July) 1920.

for success have been laid down.<sup>6</sup> Various materials have been used such as cigaret paper,<sup>6</sup> cellophane<sup>7</sup> or sheep's cecum.<sup>6</sup> Most of the reports have been concerned with patching perforations following healed infections or those of blast-damaged drums several weeks after injury. This series presented an opportunity for determining how early a patch could be used to advantage.

In placing a patch over a perforated tympanum it is clear that many materials and technics may give a satisfactory result. The following summary is given only to point out the method adopted early in this series and used exclusively thereafter.

A sterile medicine glass is half filled with cool boric acid solution. A sterile forceps and scissors being used, a patch of appropriate size to overlap the perforation is cut and placed in the solution. Processed sheep's cecum in the form of a "fish skin" condom was used as the patch material throughout. The ear canal is cleansed with alcohol-dampened applicators to remove all dead skin and cerumen. The patch is lifted from the solution on a wire loop, previously bent to accommodate the external canal. Excess solution is blotted off with a sterile cotton applicator, and the patch is gently transferred to the ear drum.

It seems that the "urge to heal" in an ear drum sometimes becomes exhausted after some weeks and requires stimulation. This is evidenced by a pale drum with no signs of healing at the edges of the perforation and particularly by the fact that the perforation remains the same in size when observed from week to week. When this situation was present, the edges of the perforation were treated with trichloroacetic acid before application of the patch.

In 42 cases the first patch applied to the drum remained in place and the ear dry. These drums presented little ecchymosis or swelling, no drainage and usually a small amount of blood at the edges of the perforation. In 17 cases the first patch was floated off by drainage developing later, but was replaced one or more times, and eventually became adherent.

In 21 ears patches were not used at all or had no influence in the healing process. In 3 of these the perforation was already sealed with a crust or a blood clot. This was left intact, and all healed well. In 3 others no patch was employed since the perforation was a simple rent or a hole of small diameter. These healed well and promptly. In 15 cases no opportunity was presented to place a patch, as aural discharge continued right up to the time of complete healing.

Seven cases were frank failures and are reported in detail in the following pages.

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<sup>6</sup> Stinson, W. D. Closure of Membrana Tympani with Cargile's Membrane, *Ann Otol, Rhin & Laryng* 50 178-181 (March) 1941.

<sup>7</sup> Henry, G. A. Blast Injuries of the Ear, *Laryngoscope* 55 663-672 (Nov) 1945.



*Healing*—All observations of healing were gross. No opportunity was presented for microscopic study. As elsewhere in the skin, in the tympanum healing proceeds only after nature has carried out its own "débridement." As experience was gained, it was found that a severely damaged drum required from five to twenty-one days to complete this process, which consisted of liquefaction of blood clots, absorption of ecchymosis and washing out by drainage any particulate matter, dead skin, devitalized drum, etc. Any attempt at patching before this process was complete, even though the ear was dry at the time, was doomed to failure, as the patch would be floated off by serous drainage. When the "débridement" was complete a patch could be applied with good assurance of success.

The edges of an actively regenerating drum exude a small amount of plasma. This seems to provide the matrix into which the growth proceeds. When a patch is applied, this plasma soon covers the whole inner surface, causing it to adhere firmly to the drum and providing a more extensive area of clotted fibrin, protected from drying, as a matrix for growth.

Several large perforations were observed to decrease in size rapidly in the first three or four days, before it was logical to assume that healing could fairly start. This was perplexing until the mechanism was observed. A blast perforation will usually not be a complete avulsion of tissue. Often the missing portion of the drum will be rolled or folded in, occasionally, owing to the negative phase of the compression wave, it will be rolled out. When this situation prevails, the rolled or folded portion of the drum is progressively brought back into position as the drum swells, much as a folded toy balloon straightens out when inflated. This process will often reduce the size of a perforation by 75 per cent in four days, provided the folded portion of the drum is viable.

*Drainage*—In 35 ears drainage of an appreciable degree developed either spontaneously or after patching. Circumstances prevented routine bacteriologic studies, but in most of the ears it seemed to be of the "débridement" type, a sluggish discharge of clear or white fluid without evidence of inflammation in the ear. General sulfadiazine or penicillin therapy had no effect in reducing the discharge or shortening the duration of drainage. This has been noted previously<sup>4a</sup> and adds weight to the proposition that this type of secretion is not of infectious origin.

One of the most striking observations on healing involved those cases in which unquestionable acute infection supervened. Seven such cases were observed, and in 6 healing of the drum was most active, prompt and complete. In 3 cases the infection developed before any treatment had been instituted. In 2 the drum healed promptly without

assistance In 4 cases the infection developed after a patch had been applied, in all 4 the perforation was healed by the time drainage ceased All infections were controlled with sulfadiazine orally and penicillin parenterally Only 1 of the 7 infected ears failed to heal (case of E M, reported on a following page), and none required mastoidectomy One typical case is presented in detail

B H was 30 feet (9 meters) from a V-1 explosion, and when he was first seen twenty-six days later the right ear drum was normal and the left presented a perforation, 5 by 5 mm, with no ecchymosis The injured ear was dry, and there was no evidence of regenerative activity There had been discharge of some clear mucus, without pain or fever, starting on the ninth day and continuing for ten days The ear had been dry for seven days when seen Without use of trichloroacetic acid, a patch was placed over the perforation Two days later severe pain developed in the ear, with copious drainage of purulent fluid, fever, and tenderness over the mastoid process Penicillin and sulfadiazine controlled the infection Nine days after the onset of acute symptoms the ear was dry and the drum completely healed

It appears that acute inflammation greatly stimulates the healing power of an ear drum This observation has been made previously<sup>6</sup> and raises the question whether it is the inflammatory process itself or the presence of bacterial toxins which provides the stimulation It also raises the question whether, under properly controlled conditions, induced inflammatory reactions should be further studied in selected ears that otherwise seem doomed to retain a perforation

*Determination of Healing*—It was early apparent that no exact date for complete healing of a drum could be given The perforation heals slowly under a patch or a crust of dried mucus and is not under direct observation At first it was felt that healing could be assumed when a patch was observed to be firmly adherent for two weeks and the drum moved well with the pressure speculum Later it became apparent that this merely indicated an airtight seal of the patch and not necessarily complete healing Accordingly, the time given for healing is the time at which the drum itself was directly observed to be completely healed, without superimposed patch or crust

Table 5 correlates the severity of damage with the time in weeks required for healing (or the period of observation with patch in place and a dry ear)

It is apparent that the time necessary for healing varies widely in each category of damage There is an indication that a severely damaged drum is unlikely to heal after eight weeks, and this is the observation that led to the remarks on "urge to heal"

Table 6 shows the results of the complete series and how they were obtained

Several facts are noteworthy Twenty-one drums healed without the aid of a patch, 16 of these being slightly or moderately damaged Thirty-four were observed to heal completely without drainage following ap-

TABLE 5—*Correlation of Severity of Damage and Time Required for Healing*

	Category of Damage	Time in Weeks																		Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Complete healing observed	A	2	1	4	3	1	1	5	2	1	3	—	1	1	—	—	—	—	—	25
	B	—	—	5	4	1	3	3	3	2	1	—	2	1	—	2	—	2	—	29
	C	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	1	—	4
	D	—	—	2	—	2	1	1	—	—	—	—	—	—	—	—	—	—	—	6
	Total	2	1	11	7	5	5	9	5	5	4	—	3	2	—	2	—	3	—	64
Ear dry patch in place	A	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
	B	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3
	C	—	—	—	3	—	—	—	—	1	—	—	—	—	—	—	—	—	—	4
	D	—	—	1	3	1	—	—	—	1	—	—	—	—	—	—	—	—	—	6
Failures	A	0																		
	B	2																		
	C	1																		
	D	4																		

TABLE 6—*Summary of Results*

		Category of Damage				Total
		A	B	C	D	
Complete healing observed	Without patch	8	8	1	4	21
	With patch after period of drainage	2	3	1	3	9
	With patch without drainage	17	17	0	0	34
Patch in place more than three weeks with dry ear		0	3	3	3	9
Patch in place less than three weeks with dry ear		3	1	1	2	7
Failures		0	1	2	4	7
Total		30	33	8	16	87

plication of a patch. All of these presented slight or moderate damage. Primarily these belonged to the group of patients for whom hospitalization was not required or early return to duty was made practicable by the protection offered by the patch.

Nine healed with the aid of a patch after a period of drainage. Most of these showed a "débridement" type of drainage rather than definite infection. Four of these were in category C or D.

Sixteen ears were dry and had retained a patch for varying periods when last seen. Though experience indicates that most of these will heal under a patch, they cannot be reported as healed. Hence they are placed in a special category.

It can be safely assumed that in the seven failures healing either will never occur or will be a matter of years. In this type of cases the drum, after a long time, occasionally manages to fill in the defect with an extremely thin, completely transparent membrane, which often can be detected only with the pressure speculum.

#### REPORTS OF FAILURES

Among the 87 drums observed there were 7 undoubted failures, that is, 7 drums which were not healed or did not have a patch firmly in place when last seen. In each case a dry ear was attained. These cases, which may be considered most instructive, are reported in detail.

CASE 1—E. M. was exposed to a V-1 explosion 60 feet away, he was prone, there was no screening, and no protective devices were being used. He also suffered injuries of the lower extremities, without appreciable shock, for which he received penicillin and sulfadiazine therapy for ten days. He was first seen forty-eight hours after injury, the left ear was draining thin serous material but was without inflammation, there was a perforation, 3 by 6 mm. The right ear was dry, but the drum showed a perforation, 4 by 6 mm. There was little ecchymosis on either side. A patch was immediately placed on the right drum, it was retained for ten days and then was floated off by thick yellow exudate. At this time, the left ear was also draining thick yellow exudate, and roentgenograms showed both mastoid processes normal. Infection was controlled with further administration of penicillin and sulfadiazine. Drainage of the right ear continued until the thirty-second day, at which time this ear was dry and the perforation healed. The left ear was dry at this time, and a patch was placed over the perforation, which was the same size as originally. On the thirty-seventh day the ear was dry, but the patch was found displaced, and another patch was placed. Two days later the ear was damp and the patch displaced. No further treatment was done until the forty-ninth day, when, the ear having remained dry in the meantime, another patch was placed. This was found displaced five days later, with the ear dry, and treatment was abandoned, the perforation being about 6 by 7 mm. No cauterizing or irritating agent was used at any time — only the boric acid-soaked patch. Hearing at the

first visit was right, 1/15, left, 1/15 Hearing at the last visit was right, 1/15, left, 1/15 Tuning fork tests indicated good bone conduction

*Comment*—It is apparent that the perforation increased in size while under observation and treatment This may well have been due to repeated irritation incident to the presence of a patch This patient was cooperative and intelligent and did not blow his nose while the patch was in place, no respiratory infections supervened

CASE 2—R J was exposed to breech explosion of a 90 mm gun 4 feet away, there was no screening, he was erect and was using no protective devices A history was obtained of frequent aural drainage in childhood but none for fifteen years past The patient was first seen the second day after injury, the left drum showed a 4 by 7 mm perforation without ecchymosis, the right, a high anterior perforation, 3 by 5 mm, with moderate ecchymosis A patch was placed on the left drum on the second day after injury, another was placed on the right drum on the sixth day The left ear retained the patch firmly and remained dry until last seen on the thirty-sixth day Over a period of a month five patches were placed over the perforation of the right drum, but each time it would be found displaced, with the ear dry, a few days later The patient was a nervous person, and it became apparent on talking to his ward mates that, in spite of repeated warnings, he would blow his nose with great vigor at any time he pleased It was felt that this was displacing the patch When last seen the perforation was 3 by 5 mm, without evidence of healing Hearing at the first visit was right, 3/15, left, 10/15 At the last visit it was right, 15/15, left, 15/15

*Comment*—Vigorous blowing of the nose will displace a patch that has not had time to become firmly sealed with plasma

CASE 3—M P underwent the blast of a V-1 explosion 25 feet (7.5 meters) away, with a heavy trailer between him and the bomb, his position was erect, he used no protective devices He was first seen six days later The right ear was 80 per cent occluded with cerumen, the drum showed a 1 by 2 mm anterior perforation, with no ecchymosis The left ear contained no cerumen, the drum showed a posterior perforation, 5 by 8 mm, with little ecchymosis and a thin white discharge A patch was immediately placed on the right drum, and complete healing was observed on the eighteenth day

The left ear was treated by dry wiping and Sulzberger powder (an iodized boric acid dusting powder) It became dry, and on the twenty-seventh day a patch was placed Three days later the ear was moist and the patch displaced On two further occasions, after long observation of a dry ear, patches were placed but were not retained On the hundred and thirty-first day after injury treatment was abandoned, the perforation having been 2 by 3 mm for the past two months Hearing at the first visit was right, 9/15, left, 4/15 At the last visit it was right, 15/15, left, 14/15

CASE 4—J A was exposed to a V-1 explosion 50 feet (15 meters) away, there was no screening, the patient was using no protective devices and was erect He was first seen five days later The right drum showed an anterior perforation, 4 by 7 mm, with some old blood and a brown discharge, ecchymosis was slight The left drum showed a 7 by 8 mm perforation, slight ecchymosis in the drum margin and a thin brown discharge Fourteen days after injury, the right ear had been dry for five days, and a patch was placed Complete healing was observed on this side on the hundred and twentieth day

For treatment of other wounds the patient was given penicillin and sulfadiazine for two weeks after injury. In spite of this and local dusting with Sulzberger powder, drainage of the left ear continued for thirty-eight days, the perforation at this time being 2 by 3 mm. On the forty-second day a patch was placed, it seemed to be well tolerated and retained, but no healing occurred under it. Fifty-two days after placement the patch was observed to be displaced, with the ear dry. After twenty days' further observation, trichloroacetic acid was applied to the edges of the perforation, and another patch was placed. This was displaced seventeen days later, with the ear dry, and the perforation was observed to be 4 by 4 mm. Treatment was abandoned at this point. At the first visit hearing was right, 4/15, left, 3/15. At the last visit it was right 13/15, left, 13/15.

CASES 5 and 6—F. W. was exposed to breech explosion of a 90 mm gun 2 feet (less than a meter) away, there was no screening, no protective devices were being used, the patient's position was erect. He was first seen on the second day after injury, both drums were completely obscured by clotted blood, which was not disturbed. On the third day the clots started to liquefy and there was a sluggish brown discharge. Boric acid irrigations were started. On the fifth day the blood had cleared, revealing on the right a 4 by 7 mm perforation and on the left a double perforation, one 4 by 4 mm on the posterior part and one 4 by 7 mm on the anterior part of the drum, with moderate ecchymosis on each side. Both ears continued to drain until the twenty-fourth day during a course of treatment in which sulfadiazine was followed by penicillin. Four days later a patch was placed on the left drum but was found displaced, with slight drainage, the following day. Two more attempts were made to patch this drum, with the same result each time.

On the thirty-eighth day a patch was placed on the right drum after use of trichloroacetic acid. This remained in place for ten days, at which time it was displaced and the ear moist. On the sixty-third day, both ears were dry, and treatment was abandoned. At this time the perforation of the right drum was 4 by 7 mm, while the two perforations of the left had coalesced into one, 6 by 8 mm. Both ears were reported as failures. Hearing at the first visit was right, 9/15, left, 2/15. Hearing at the last visit was right 9/15, left, 10/15.

*Comment*—These ears both demonstrate the occasional intolerance of an ear drum to the presence of a foreign substance. The deleterious effect of the repeated spells of low grade drainage is shown by the coalescence of perforations on the left.

CASE 7—D. P. was exposed to a V-1 explosion 30 feet (9 meters) away, no screening, no protective devices and position prone. He was first seen eighteen hours after injury, the drum showed a 6 by 8 mm perforation, the left ear, a double perforation, a posterior one, 2 by 3 mm, and an anterior one, 3 by 4 mm. There was moderate ecchymosis on both sides. Both ears drained clear mucus, which later became thick and yellow, throughout a course of treatment in which sulfadiazine was followed by penicillin. On the twenty-first day the left drum was observed to be completely healed, no patch having been used. Sluggish

drainage of clear mucus continued on the right until the fifty-eighth day. On the sixtieth day a patch was placed but was found displaced by clear mucus the following day. Several days later, because of other wounds, the patient was evacuated, the perforation of the right drum was still 6 by 8 mm and the ear dry. At the first visit hearing was right, 1/15, left, 1/15. At the last visit it was right, 12/15, left, 12/15.

From the résumés of case histories several facts emerge. 1. Failures usually occur in the most severely damaged drums, though from observations in other cases in the series it is clear that no definite prognosis can be given at the first examination, as some of the most severely damaged drums will heal well.

2. It is advisable to desist from attempts at patching if intolerance is demonstrated by two drainage reactions to patches, as further attempts may enlarge the perforation.

(It is probable that in several instances in this series the patch was applied too soon after a period of drainage, and that success would have been more likely had a dry ear been observed for a longer period. Two considerations enter here. 1. The patch should be applied, if possible, before the "urge to heal" is exhausted. 2. In an active theater of operations the conscientious medical officer will wish to return patients to duty as early as is possible with safety. Had unlimited time been available many of the ears would have been observed for a longer period after drainage before patching.)

3. Cooperation of the patient is essential to success, even with a small perforation.

#### SUMMARY AND CONCLUSIONS

A series of 87 perforated ear drums is presented in each of which the damage was due solely to the compression wave from a blast.

Twenty-one drums healed without assistance.

Patches of processed sheep's cecum were placed over 59 perforations. In 43 of these perforated drums healing was observed to progress until it was complete, 9 of the remaining ones had retained the patch, with the ear dry for three weeks or more when last seen, 7 had retained the patch with the ear dry, for less than three weeks when last seen.

Seven drums were frank failures, the ear was dry but the perforation persisted when last seen, and would not retain a patch in spite of repeated tries.

By the whispered voice test, a marked loss of hearing is noted when the patient is seen early. In the great majority of cases, over a period of weeks, the hearing returns to normal.

The most striking observation was the rapidity with which a damaged drum will heal when an acute febrile infection of the middle ear supervenes. This suggests the possibility that a further study should be made of inflammatory reactions induced under controlled conditions, in perforated drums which seem otherwise destined never to close.

A natural process of healing is described by which a large perforation will often be reduced in size by 75 per cent in the course of the first few days.

There is a definite need for a simple, systematic and universally applicable method of classifying clean traumatic perforations of the tympanum. This paper presents such a classification. Adoption of such a system will provide a yard stick for measuring the efficiency of any method of treatment in the future.

Actual acute suppurative infection of the middle ear occurs infrequently in cases of this type of injury (in 8 per cent of cases in this series) and appears to be controllable with sulfadiazine and/or penicillin administered generally. In no case was mastoidectomy required. When acute suppuration does occur, it is almost always accompanied by a definite and prompt stimulation of healing.

A low grade, noninflammatory, "débridement" type of discharge of clear or white mucus occurs frequently (in 33.4 per cent of cases in this series) and is not affected by chemotherapeutic agents or antibiotics. Most of the failures are considered due to recurrent drainage of this type.

The time required for complete healing varies considerably in the different categories of damage.

If an ear is dry and the perforation is covered with a crust or with dried blood, this should be left strictly alone. The drum will heal under the crust. On this point there is no disagreement. A very small perforation or a simple rent will also heal promptly.

Treatment of open perforations varies. From this series it would appear that patching a small or a moderate perforation that is without drainage protects the middle ear from dirt and water and permits safe early return to duty.

Against this must be laid the danger (demonstrated in 2 of the failures) of inducing a larger perforation. Certainly, if a patch is to be used, there is an optimum time to place it—when the natural "débridement" is complete and while the regenerative powers of the drum are still active.



Failure to heal usually occurs in the most severely damaged drums. Prognosis, however, should be guarded, as some of even the most severely damaged drums heal well.

If drainage reaction follows two successive applications of a patch, it is advisable to desist from further attempts for at least two months.

From the Division of Surgery, Department of Otolaryngology, University of California Medical School (This work was done by the author while he was with the 30th General Hospital, an affiliated unit of the University of California Medical School.)

Dr. Lewis F. Morrison, clinical professor of otolaryngology of the University of California Medical School, gave assistance in the preparation of this paper.

## Case Reports

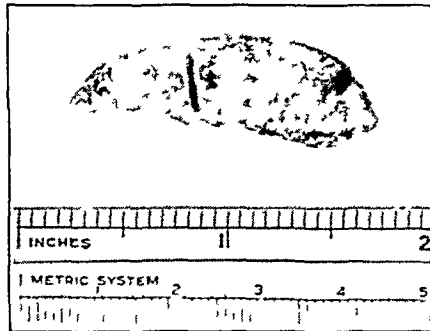
### CALCULUS MAJOR

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**I**T IS ALWAYS interesting to note how extensive pathologic conditions may become before a patient is forced to obtain relief

#### REPORT OF A CASE

This patient gave a typical history of swelling of the submaxillary gland, worse after eating, which had been intermittent for two years. A physician saw the patient two years before but told him that he did not do this type of work and failed to refer the patient to anyone who could help him.



Calculus removed from patient

Examination revealed a swollen right submaxillary gland with marked swelling of Wharton's duct and an extensive area of stony hardness. A probe met a dead end 1 cm from the ampulla, and there was purulent secretion from the duct after probing. The gland and duct on the other side were entirely normal.

Under local anesthesia the duct was incised but, as may be imagined, the incision had to be enlarged several times. The calculus was removed intact, the fracture being caused by later handling by the patient. The wound healed promptly and completely. The patient remains symptom free.

As seen in the photograph, the stone measured 37 by 12 mm. When dry it weighed 2.95 Gm.

## Book Reviews

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**Twentieth Century Speech and Voice Correction** Edited by Emil Froeschels,  
M.D. Price, \$6 New York The Philosophical Library, Inc., 1948

In reading this book, the reviewer gained the impression that it was not carefully planned or edited. It lacks uniformity, some chapters dealing with theory, some with practice, and still others with mere description. The first chapter acquaints the reader with a knowledge of the anatomic and physiologic aspects of the speech mechanism. The succeeding chapters follow no logical order and seem somewhat unrelated to each other. They are more like a series of articles than chapters of a single book.

The volume contains twenty two chapters, written by nineteen authors. The subject matter includes six chapters on various aspects of deafness, four chapters on problems of the patient who has a cleft palate, and three on voice training. Other chapter titles include aphasia, dysarthria, dyslalia, stuttering, cluttering and alalia.

Unfortunately, this book has little to offer to the otolaryngologist. In the first place, the foreword does not indicate clearly the type of reader for whom the book was written. There is no one point of view presented, and the writing is uneven from author to author. Most of the chapters are too brief and superficial to arouse the reader.

One may point out just a few specific examples of weakness. The chapter on dysarthria is concerned only with cerebral palsy. The chapter on alalia is not clear and contains several instances of careless writing, for example, the author states, "Thus we may consider alalia as a corollary either of maldevelopmental conditions (effector or associative or both) or of a psychopathic personality" (page 66). The author certainly cannot be using the term "psychopathic personality" as defined by the psychiatrist. In the chapter "Acoustic Education in Children," one finds a statement of doubtful theory. "According to recent theories the acoustic centers of the cortex quasi are 'loaded' with 'stimuli' until they are sufficiently 'charged' to produce acoustic identifications, concepts and spontaneity of acoustic patterns and conscious vocal production" (page 103). This implies that "stimuli" are stored in the nervous system! The chapter entitled "Remedial Reading and General Semantics" makes no contribution to speech and voice correction.

The editor, as author, and several of his students, as co-authors, present a theory concerning the close relationship between chewing and the mechanics of speech. They show how the chewing method may be utilized in the correction of stuttering and hyperrhinolalia and in the education of the singing voice. Several chapters, such as the one on hearing rehabilitation, offer rather thorough outlines of procedures. This chapter describes the program used in a government rehabilitation center. It is well done. Special attention should be called to the chapter "Voice Training After Laryngectomy." This is an excellent piece of work and contains information seldom found in other publications. Other chapters of equal merit are "Aphasia," "The Education of the Deaf Child," "Dyslalia" and "Dis-

orders of Articulation Due to Gunshot Wounds of the Head and Neck in World War II" The authors of these chapters present a sound approach and offer specific data and suggestions to the reader

It is difficult to write a short review of a symposium type of book Although the book as a whole is disappointing, for reasons already mentioned, the reviewer hopes he has not done an injustice to those authors whose chapters can be recommended

**Practice of Allergy** By Warren T Vaughan, M D Revised by J Harvey Black, M D Edition 2 Cloth Price, \$15 Pp 1132, with 333 illustrations St Louis The C V Mosby Company, 1948

The second edition of this popular work is timely As stated in the preface, considerable new material has appeared and much has been removed which has become unacceptable, owing to the changes and better interpretation of the newer facts and theories of allergy

The book is extremely comprehensive and can serve as a one volume encyclopedia for the allergist Considerable space is devoted to the theories of the nature and the environmental influences of this disease Sufficient space is devoted to physiology and diagnosis Probably the most important phase of the book deals with pollens and pollinosis, methods of collection, and distribution throughout the United States The method of making extracts and the determination of proper dosage are given a great deal of space The chapter on food allergy is also extensive and the diet lists are abundant Contact and physical allergy also receive considerable discussion

Perhaps more space should have been devoted to the generalized evidences of allergy, such as migraine, gastrointestinal allergy, particularly that in children, Menière's disease and otorhinologic manifestations of allergy The chapter relating to otorhinologic allergy is extremely skeletonized and could be expounded in greater detail The bibliography is extensive, but the index has many important omissions and should receive a more careful revision

In spite of this criticism, the book is well written, easily comprehended and printed on good paper Every allergist and general practitioner should have a copy of it on his desk

**Diseases of the Ear, Nose and Throat** By William W Morrison, M D Pp 772 New York Appleton-Crofts, Inc, 1948

This book is one of the most outstanding contributions of its type in many years Intended for undergraduate students and general practitioners, it should equally be of inestimable value to otolaryngologists

It is simply written, and the text has been thoroughly digested, organized and masterfully presented It is up to date, and the modern material has been evaluated with mature and keen discrimination Obsolete theories and treatments are omitted Common diseases are stressed, and rare conditions are briefly but adequately described The text reflects sincerity, straightforwardness and many years of teaching and thought

The book is a general comprehensive review of otolaryngology The first section emphasizes subjects of general importance, such as anesthesia, history and examination This is followed by an excellent section on modern drug therapy Each of the following sections is preceded by a brief anatomic review and in-

corporate a comprehensive discussion of the physiologic and pathologic aspects of the parts concerned. Symptoms and signs of diseases are enumerated in the order of their importance. Only specific treatments or those that have stood the test of time are presented.

There are no impressive colored prints, but the author's diagrammatic drawings emphasize extremely effectively the points he wishes to explain or stress. He does not attempt to describe detailed surgical procedures but suggests the basic principles.

There is an ingeniously arranged symptom and subject index consisting of 60 pages. One must agree with the comment in the foreword that "Morrison's book will render conspicuous service in stimulating and stabilizing American otolaryngology in the years ahead."

## HYDRODYNAMICS AND HEARING

I *The Operative Relief of Otosclerotic and Nonotosclerotic Deafness and Its Relationship to a Hydrodynamic Hypothesis of Hearing, a Suggested Explanation for*

(a) *the Intimate Association of the Organs of Balance and the Organ of Hearing and for (b) the Function of the Incus*

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THE DISCUSSION on hearing started four hundred years ago and the argument still continues. It is therefore with some apprehension that any one attempting the reorganization and reorientation of ideas on this subject approaches such a task. That operative procedures have restored hearing in various forms of deafness is now an accomplished fact, and whereas it may at one time have been permissible for theories of hearing to remain comfortable academic abstractions reserved for physicists and physiologists, Lempert in the last decade has revolutionized the situation. Once otologists are able to restore hearing by operation it becomes essential for them to understand how the human being hears, and theories of hearing may no longer remain in the esoteric sphere.

It is my belief that otologic teaching must be revised and that the hydrodynamic hypothesis offers a satisfying explanation for many phenomena in this complex function.

### LEADING QUESTIONS

*What Is Meant by Hydrodynamics?*—The hydrodynamic conception of hearing postulates certain premises. The stapes is a mobile member which seals the outer wall of the column of perilymph in the perilymphatic sinus of the vestibule. The elastic round window membrane seals the column of perilymph in the scala tympani. These two columns of fluid are completely separated by a gallery—the lamina spiralis ossea with the attached basilar membrane. These fluid columns communicate freely with each other at the apex of this gallery (helicotrema). They thus form a perfect hydrodynamic system—a continuous column of fluid, rigidly enclosed, with mobile sealed ends.

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Read before the Section on Laryngology, Otology and Rhinology at the Ninety-Seventh Annual Session of the American Medical Association, Chicago, June 24, 1948

In a paper published elsewhere<sup>1</sup> I briefly indicated a hypothesis based on hydrodynamics to account for the improvement of hearing following fenestration in otosclerosis

*How Does Fenestration Restore Hearing and Is Such Restored Hearing Normal?*—In otosclerosis the stapes is gradually immobilized, the process beginning with limitation of movement and proceeding finally to absolute fixation, and in that event the stapes ceases to function as an escape valve. There is mechanical resistance to pressure. The perilymph is impeded. Its vibrations are no longer allowed free play. They are dammed back and dampened. From these attenuated impulses the organ of Corti receives a correspondingly weaker stimulus, and deafness is established, deafness due in the early phase of otosclerosis purely to the circumstance that a reduced stimulus is reaching a functionally perfect organ of Corti. The latter's potential is unimpaired. It is the stimulus that is at fault.

Clinical otosclerosis is not deafness but a breakdown of the hydrodynamic cochlear system. Stapedial fixation has converted the latter into a tube rigidly sealed at one end. Deafness happens to be the predominating symptom of this breakdown.

To restore hearing, a new escape valve, to remove the mechanical barrier, must be created to restore the hydrodynamic system and to reestablish mobility of the perilymph. Fenestration achieves this—but this only, and no more. The fixed stapes is by-passed and ignored. Fenestration does not, and never can, restore normal hearing. It can restore hearing to or above the serviceable level of the 30 decibel loss. To promise normal hearing would imply restoration of the exquisite function of accommodation. This is irretrievably lost, in any case, in otosclerosis.

*The Stapes, the Perilymph and the Round Window Membrane—What Is Then Protective Role?*—It has already been shown how the mobile stapes by accommodating the excursions of the perilymph is essential for the normal perception of sound. This accommodation must then be considered as its first function.

One must now consider what happens when the stapedius muscle contracts. Lempert has maintained that the function of the stapes is to protect the cochlea. I would go much further. The following argument is intended to demonstrate that the stapedial apparatus not only directly protects the organ of Corti from injury but guards the whole organism from the peril of surprise attack. Should stimuli or noise be excessive and likely to injure the organ, the stapes is able by muscular

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<sup>1</sup> Popper, O. Fenestration of the Labyrinth, *J. Laryng. & Otol.* **61** 441-458 (Aug.) 1946

action (the stapedius muscle) to control and adjust excessive excursions of the perilymph or partially to immobilize it. Contraction of the stapedius muscle pulls the footplate of the stapes out of the oval window.<sup>2</sup> This

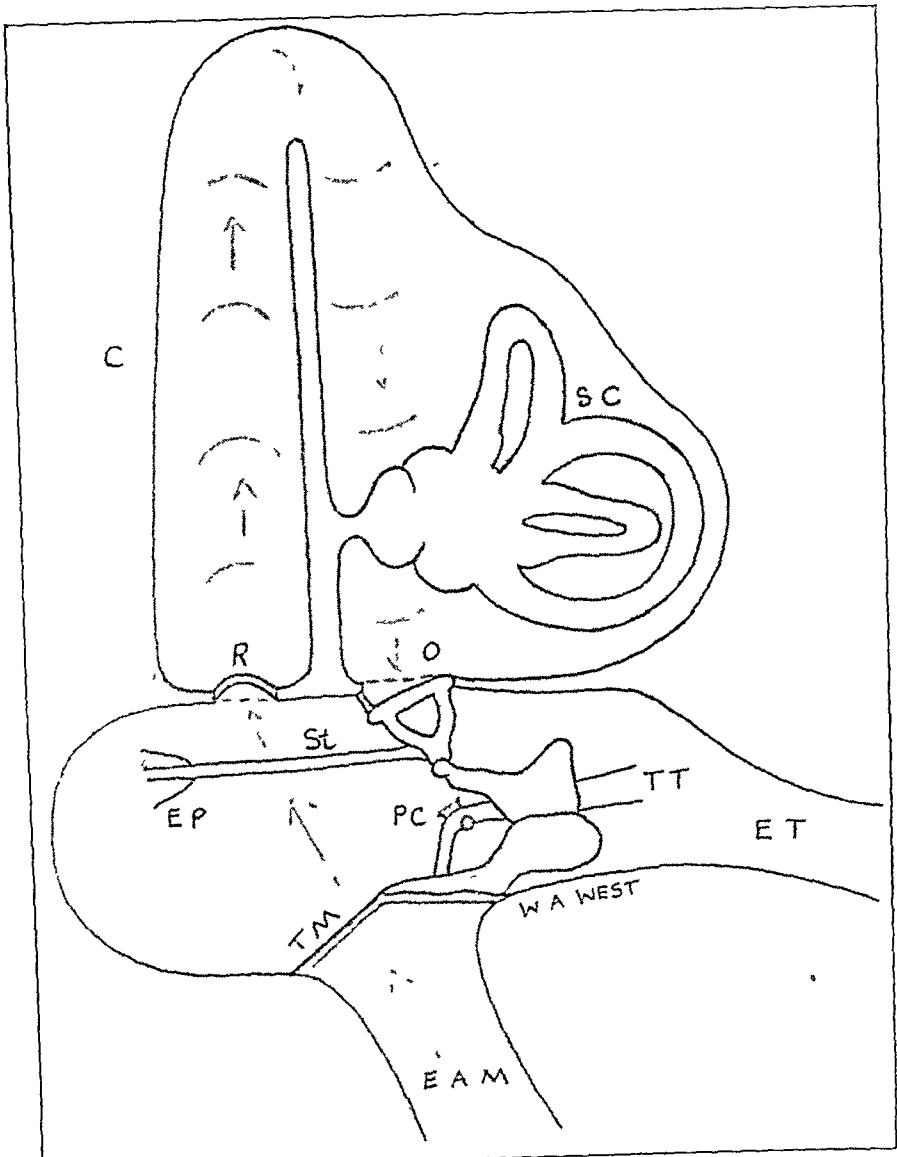


Fig 1—Mechanism of hearing. The diagram illustrates schematically how the positive phase of a sound wave acts on the round window membrane. The membrane bulges inward and the stapes hinges outward. *C* indicates the cochlea, *SC*, the semicircular canals, *R*, fenestra rotunda, *O*, fenestra ovale, *ST*, stapedius tendon, *EP*, eminentia pyramidalis, *PC*, processus cochleariformis, *TM*, tympanic membrane, *TT*, tensor tympani, *ET*, eustachian tube, *EAM*, external auditory meatus.

<sup>2</sup> Sir Thomas Wrightson has shown that the footplate actually hinges posteriorly and, therefore, contraction of the stapedius would pull the footplate out of the oval window.

A hydrodynamic system acts equally well in reverse and for purposes of clarity in the schematic diagrams, contraction of the stapedius is shown to pull the footplate into the oval window.



causes the elastic round window membrane to be drawn in at the opposite end of this hydrodynamic system. The stapes acts as a damper. This dampening protects the organ of Corti from harmful stimulation—an active involuntary cochleostapedial reflex.

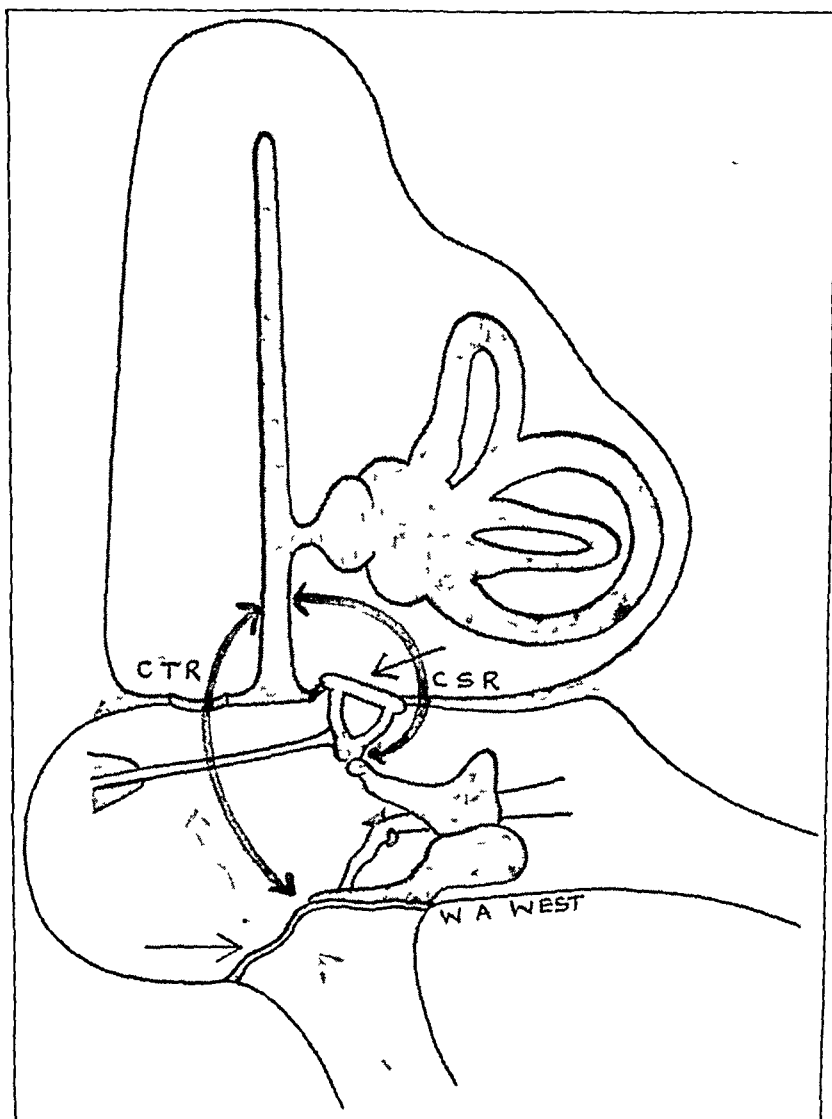


Fig 2—Mechanism of protection against excessive sound. The tympanic membrane is relaxed. There is inward movement of the stapes, with a dampening effect on the perilymph to protect the organ of Corti against injury. *CTR* and *CSR* indicate the cochleotympanic and the cochleostapedial reflex, respectively.

Two hundred years ago, Du Verney suggested an attractive theory that the two membranes (the drum and the round window membrane) by varying their tension were capable of increasing the intensity of sounds or a selected portion of the sound spectrum.

It is generally suggested that the ability of a musical ear to pick out instruments in a full orchestra is a central function. Similarly an animal is able to pick out certain portions of a sound spectrum in order to protect itself against the peril of unexpected attack. The devastating conclusion that the musical ear is a throwback, a form of atavism, is inescapable. Bismarck of the treble voice and black heart, master of

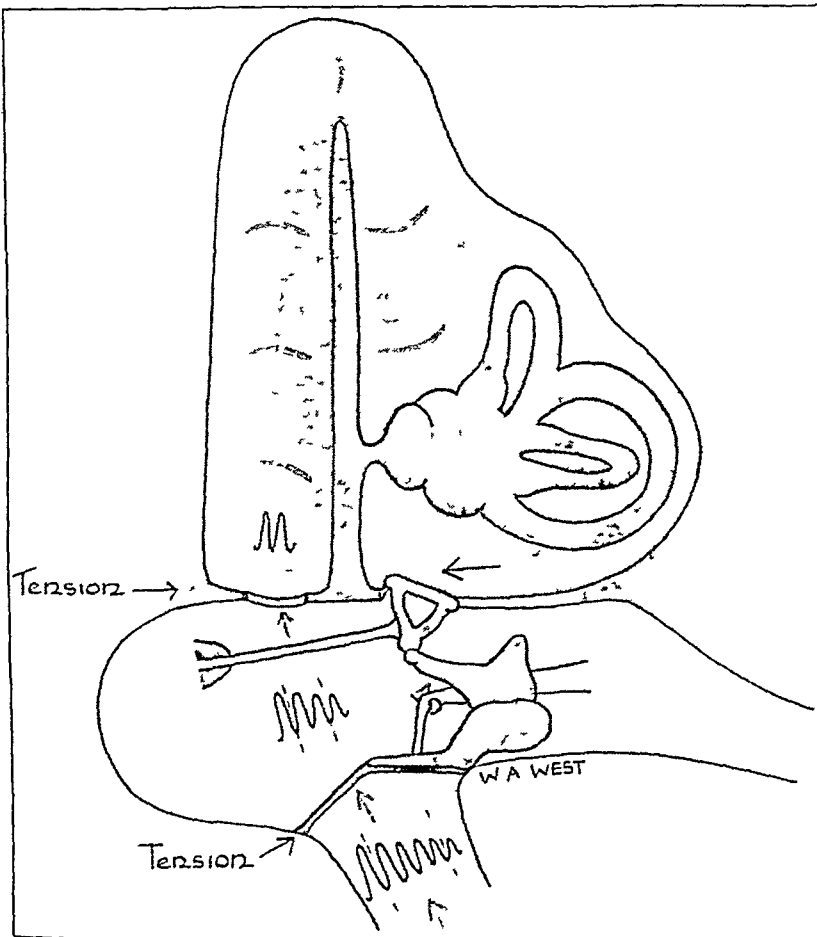


Fig 3—Mechanism of selection. The stapes is hinged inward. The round window membrane is tensed outward. The tympanic membrane is tensed by the tensor tympani tendon. Thus a focusing on a selected portion of the sound spectrum is achieved.

intrigue, forger of telegrams, to whom all music was an unpleasant form of noise, would rate high in an evolutionary sense.

The man that hath no music in himself,  
Nor is not moved with concord of sweet sounds,  
Is fit for treasons, stratagems and spoils,  
The motions of his spirit are dull as night,  
And his affections dark as Erebus,  
Let no such man be trusted—mark the music

Shakespeare certainly had something there

*Why Are the Organs of Balance and the Organ of Hearing so Intimately Related to One Another?*—Every worker in this field sooner or later comes up against the same impasse—to explain the connection between hearing and balance. It seems to me that no compromise is possible until this mystery is cleared up. Embryologists have demonstrated in no uncertain manner that philogenetically these organs belong together and have left it at that. Physiologists and neurologists have diverted their energies in other directions. It is my hope that on the basis of applied mechanics and hydrodynamics this dark corner will be illuminated.

When first confronted with the fact that the vestibular apparatus and the organ of hearing are so closely related, one finds it difficult to understand why two such totally different organs having functions in no way related to each other are suspended in the same medium (perilymph), occupy a common site and share the same endolymph. In the one case the interpretation of movement, direction and position, and in the other the interpretation of sound, is the function. Yet they are intimately connected by the common endolymph, the perilymph and, above all, the cochlear duct, which is an outgrowth from the membranous sacs of the vestibular organ. Ever pursuing the utmost in economy, evolution has designed this contiguity. It is necessary to search for a common denominator of the complex functions as represented by the semicircular canals with their ampullae, the utricle and the saccule which will correlate with properties peculiar to the spiral organ of Corti.

There seems only one fundamental basis for a logical sequence of reasoning. Each one of these organs is designed to measure the most infinitesimal differences of fluid pressure due to movement. The endolymph in the membranous canal by inertia momentum stimulates the receptive organs in the ampullae which interpret movement in the three planes of space. In the case of the utricle and the saccule, gravity bends the hair cells loaded with their otoliths in one or other direction, and thus they interpret the position in space of the body at rest. Infinitesimal pressure effects determine the position of the body both in motion and at rest, and also give rise to protective postural reflexes. In the case of the spiral organ of Corti the same principles apply, and it also responds to minute differences of fluid pressure due to movement. Whereas the stimulus in the ampullae of the canals (inertia force) and in the utricle and the saccule (gravity) may be called a continuous pressure, in the case of the cochlear organ the pressure stimulus changes its magnitude and direction in a periodic manner. In man the cochlea is able to interpret pressure periodicities varying from 16 to approximately 30,000 cycles per second, which covers the human sound spectrum. A common denominator is thus established for the entire labyrinth.

as the interpreter of minute differences of pressure, continuous or periodic, and the contiguity of the organ of hearing and the organ of balance becomes comprehensible. It will be noted that in the case of the vestibular apparatus it is the endolymph and not the perilymph that stimulates the ampullae or the sacs. The perilymph acts merely as the suspensory medium for the membranous vestibular organ. In the organ of hearing, however, the perilymph is made use of for an entirely different purpose. Here it acts as the transmitting medium for the sound impulses and the whole mechanical arrangement of the cochlear apparatus is so adapted as to permit it to perform this function. For such free movement to occur the receptive organ of Corti must be disposed in a suitable mechanical system to allow of the fluid reciprocal excursions around it. Only a continuous tube each end of which has a freely mobile member will permit this—a hydrodynamic system. The cochlea is such a hydrodynamic system. It consists of two tubes, the scala tympani and the scala vestibuli, communicating at the apex (helico-trema). The column of perilymph is thus continuous. The endolymph within the cochlear duct does not of itself initiate pressure differences. These are transmitted to it by the excursions of the perilymph.

#### A PERTINENT COMPARISON

Before submitting a patient to the Smithwick operation, one would want to know, first, why this procedure reduces blood pressure and, second, its scope and limitation. In order to check exaggerated and absurd claims regarding improvements of hearing following fenestration a similar attitude seems imperative. The question "How do we hear?" can no longer remain a comfortable academic abstraction. A controversy which began in the sixteenth century must therefore be revived and revised.

#### HOW MAN HEARS FUNCTION OF THE OSSICLES

The fact that the three ossicles have always been referred to collectively as a "chain" is nothing short of a calamity. The very term by subconscious association is an insistence that they act together as a link. Whereas, in fact they have each an individual function and indeed are individually derived from different sources. The malleus is developed from Meckel's cartilage. The incus is derived from the quadrate cartilage, and the whole hyoid arch goes into the development of the stapes, which should have given otologists a clue of its enormous importance. That separate origins should indicate separate functions seems an inescapable conclusion, and yet search through current literature fails to illuminate these functions.

*Stapes*—The functions of the stapes have already been considered (1) to accommodate excursions of the perilymph in hearing and (2) to

create differences of pressure between the two windows (*a*) for the protection of the organ of Corti against injury and (*b*) for the protection of the whole organism

*Incus*—Excursions of the stapes are exquisitely adjusted by the tendon of the stapedius muscle, which is inserted into the neck of the capitulum above the relatively long crura as these dip down to be attached to the footplate. Nature aims at lightness, leverage and mechanical efficiency.

With this leverage the infinitesimal and exquisitely delicate excursions of the stapes would be impossible to control if the capitulum were not kept in the same plane of movement. The muscular force is applied relatively far away from the footplate. Were the latter to cant or twist

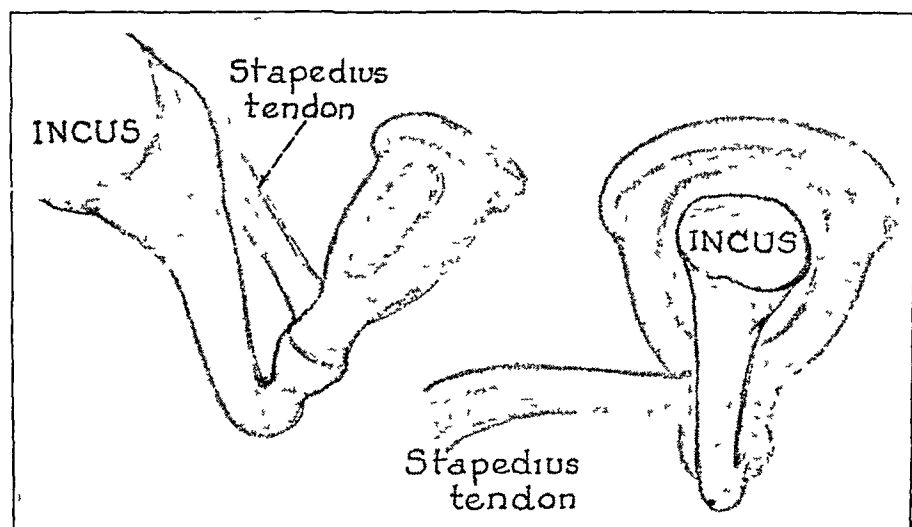


Fig 4—Function of the incus. This shows how beautifully the lenticular process of the incus is adapted to center and poise the capitulum of the stapes.

one way or the other, adjustments within such minute limits would be out of the question. It is essential that the capitulum of the stapes be permitted to move only in one plane. The lenticular process on the long crus of the incus insures this. By its elastic attachment, it centers the capitulum of the stapes and limits its movement within that plane. Clearly then, the radical mastoidectomy that indiscriminately removes this ossicle irreparably injures the mechanism of hearing. The capitulum must remain delicately poised and centered.

Another function of the incus is to support the articular surface of the head of the malleus (see later paragraph). A third function must now be considered.

The incus, by its elastic attachment to the capitulum of the stapes, opposes the tonic action of the stapedius muscle. No other balancing

mechanism exists which would prevent the stapedial footplate from being pulled out of the oval window. This would dampen vibrations of the perilymph and cause deafness.

Clearly, unopposed action of the stapedius muscle is in the highest degree undesirable. The sacrifice of a healthy incus is unthinkable. Yet, using the gentlest manipulation and exercising the greatest possible care, the surgeon often sees this happen in the radical mastoidectomy. The attachments of this ossicle are fragile.

To prevent irreparable permanent deafness when the incus has been removed and the stapes is mobile, contraction of the stapedial muscle must be prevented. The surgeon must therefore divide the stapedial tendon—a labor of a few seconds—so that hearing is preserved.

It has been shown experimentally that the stapes will vibrate with twice or even three times the amplitude after the tendon has been cut.

The stapes is then free to accommodate perilymph excursions but is no longer capable of dampening the perilymph to protect the cochlea against injurious noise or to adjust the tension of the round window membrane to filter out unwanted portions of the sound spectrum.

The functions of the incus may be summarized thus:

- (1) To poise and center the capitulum of the stapes so that movement caused by contraction of its muscle will be restricted to a prescribed orbit or plane.
- (2) To oppose the tonus of the stapedius muscle and prevent the permanent deafness that would result if the footplate were pulled out of the oval window, with resultant dampening of the perilymph.
- (3) To support the articular surface of the head of the malleus.

*Malleus*—The function of the malleus is obvious. It adjusts the tension of the tympanic membrane by action of the tensor tympani muscle.

#### A SURGICAL CLASSIFICATION OF CASES CONFORMING WITH THE HYDRODYNAMIC HYPOTHESIS

The foregoing pages, as indicated by the title, form only a part of the "Introduction to the Hydrodynamic Hypothesis." Experimentation and research are continuing. Further communications will appear in due course when sufficient material has been collected. Such material—especially results bearing on the operative restoration of hearing in cases of hypotympanic deafness—should be available from all centers where the transtympanic approach is carried out.

The transtympanic approach described elsewhere in this issue is ideally suited for the clearing of the hypotympanum with minimal trauma. A practical surgical classification suggests itself when operative measures are resorted to for the restoration of hearing in conformity with the

hydrodynamic hypothesis When the opening at the oval window end of the system is the cause of deafness, as in otosclerosis, the fixed stapes sealing the oval window, the condition, in this surgical classification, would be called (1) *stapedial deafness*, obstruction to sound reaching the round window region would be termed (2) *hypotympanic deafness*, and to both of these groups must be added (3) *irreversible deafness* when irreversible changes in the cochlear organ indicate degeneration

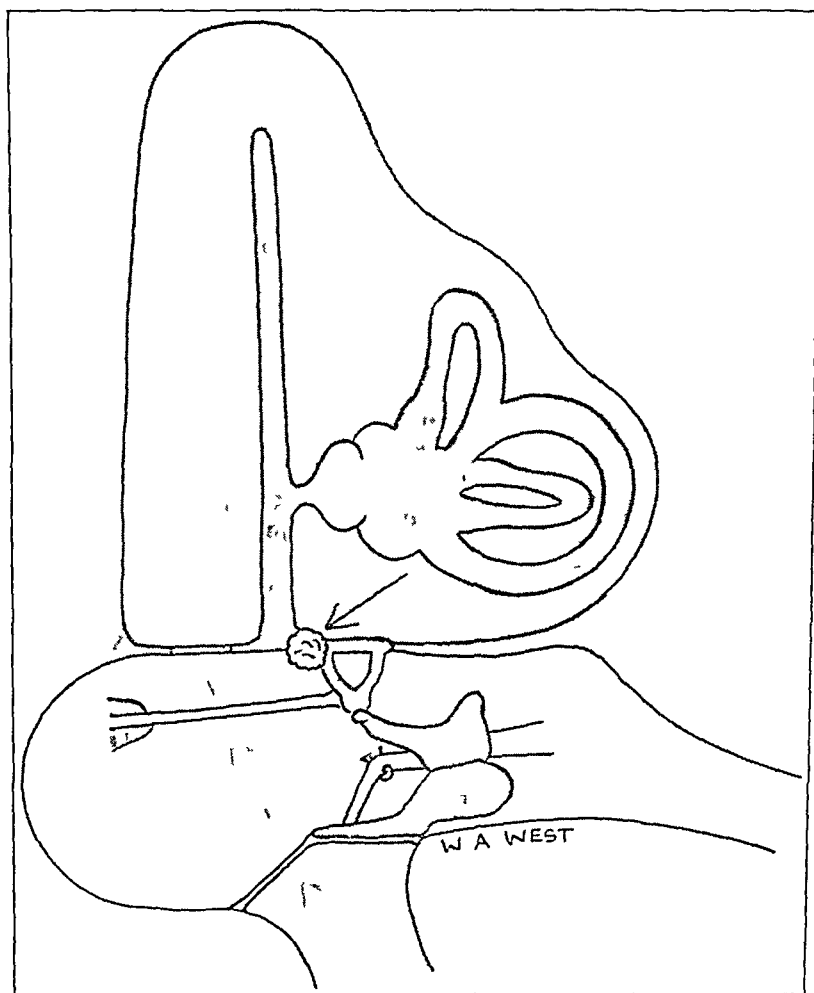


Fig 5—Mechanism of sclerotic deafness The hydrodynamic system has been destroyed An inward excursion of the round window membrane is impossible The perilymph is static (An attractive hypothesis, as yet without any experimental corroboration, suggests itself to account for paracusis willisiana The perilymph is now a "silent" pool in a closed system Where both windows are mobile, the perilymph is in a constant state of movement or turbulence In order to produce any movement of the static perilymph, the inertia of rest must be overcome, therefore, sound must be of sufficient amplitude to overcome such inertia and to have, in addition, sufficient reserve to excite the organ of Corti Where the perilymph is already in motion as it would be when the otosclerotic patient is in surroundings where vibration is transmitted through the skeleton, a lesser stimulus would possibly suffice, as the inertia of rest has been overcome by the external vibration)

In this paper evidence has been led to support the view that the round window is part of the sound pathway. It has further been shown that the deafness of otosclerosis is due to a breakdown of the hydrodynamic system. In otosclerosis the sound stimulus is ineffective despite a clear sound path (the round window) and an unimpaired organ of Corti. The exit portion of the system is sealed. Otosclerosis is not deafness but a breakdown of the hydrodynamics in which deafness is the predominating symptom. By creating an opening in the exit limb of

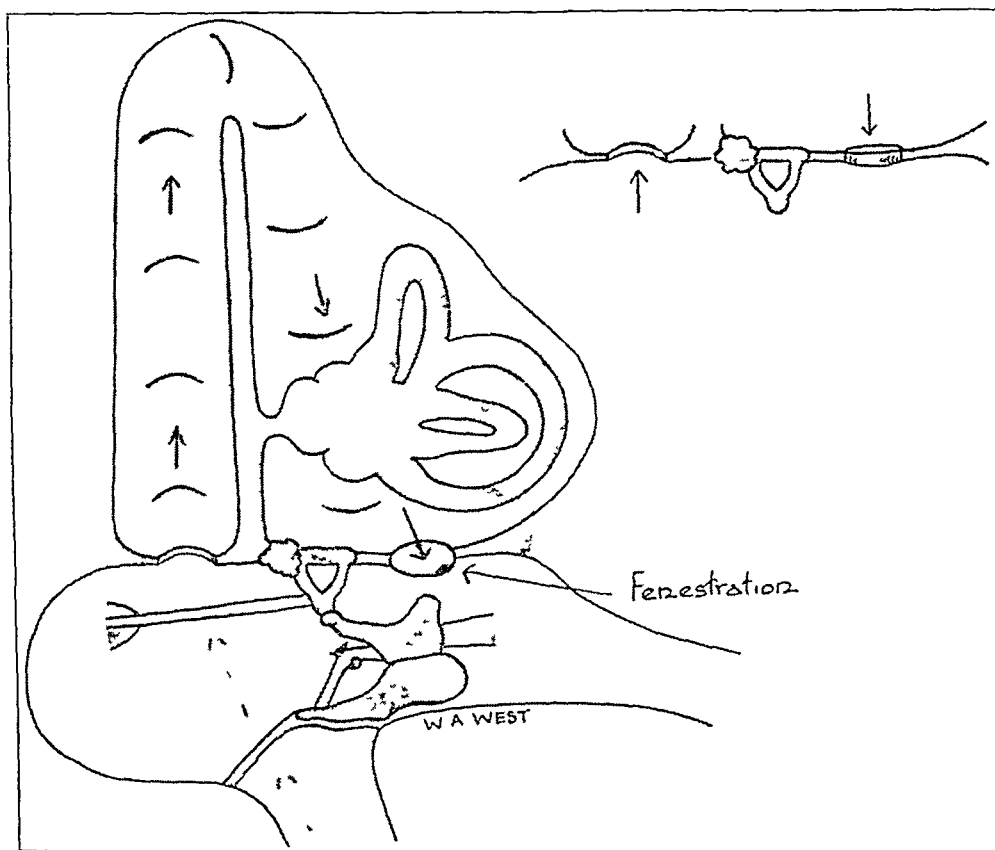


Fig 6—Restoration of hearing by fenestration. With creation of an escape valve, the round window membrane bulges inward with the positive phase of the sound wave. The detail at the upper right illustrates the effect of the Lempert cartilage stopple. The cartilage, acting as an escape valve, prevents direct stimulation of the perilymph. The elasticity or mobility of the cartilage accommodates perilymph excursions. There is normal entry of sound through the round window.

this system—fenestration of the vestibule—the cochlear apparatus again functions as a hydrodynamic system, and hearing is restored.

#### CASES OF HYPOTYMPANIC DEAFNESS

This is a vast group in which hearing by air conduction has become impaired in consequence mainly of chronic otorrhea and suppuration, the impairment being directly due to the accumulation of granulations



polyps, fibrous tissue or hyperplastic processes which obliterate the hypotympanum and the region of the round window. A series of patients were operated on for chronic suppuration and deafness. Each had a densely sclerosed mastoid process, and the infection was confined to the attic. Bone conduction revealed that the organ of Corti was relatively unimpaired. This established the correctness of the assumption that the loss of hearing was due to inability of sound to penetrate the

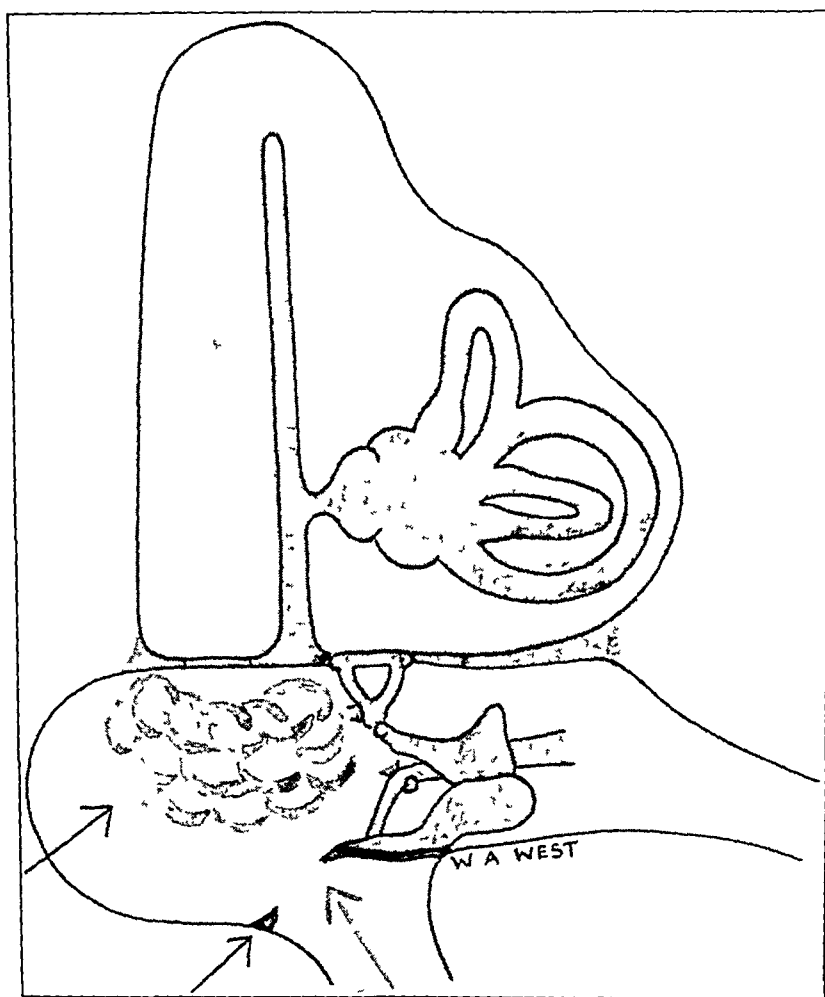


Fig 7—Transmission deafness. The diagram shows a cushion of hyperplastic tissue, polypi or granulations in the region of the round window occurring with a tympanic defect. The hydrodynamic system is unimpaired, but sound impulses cannot reach the round window membrane, the perilymph is static, therefore, these patients have paracusis as well as deafness.

cushion of tissue overlying the hypotympanum. In this condition, unlike otosclerosis, the hydrodynamic system is intact and the stapes is mobile but the organ of Corti is isolated and inactive because the sound impulses are prevented from reaching it by the obstruction at the entry of this system. Such a condition, therefore, has been termed hypotympanic deafness.

In 27 cases the transtympanic technic was employed to clear the attic and the hypotympanum. The densely sclerosed mastoid process was left untouched, and the ossicles were preserved when possible. When it was not possible to preserve the incus, the stapedial tendon was divided (in 5 cases). In 7 cases the disease had involved the incus, its lenticular process had been destroyed and the capitulum of the stapes could not be identified. With the transtympanic technic, exposure of the round window region presents no difficulties whatsoever. In every one of these cases the hypotympanum was carefully cleared of every vestige of granulation, polyp or hyperplastic tissue until the fossula of the round window was completely exposed. The entire attic was cleared of all infected bone right up to the tegmen tympani. Great care was exercised to preserve the incus, whose function has already been indicated in this paper. Eighty per cent of the patients exhibited a dry ear within three weeks. The same percentage had an immediate postoperative hearing improvement that amounted almost to normal hearing. This was spontaneously commented on by these patients and was a most gratifying result. It must be remembered that in cases of chronic hypotympanum deafness the patient is accustomed to regard the ear as useless and the organ has been written off for years as functionless. Any improvement that may result from the operation comes in the nature of a dramatic surprise.

With the revision of conceptions of hearing, and more particularly with reference to the hydrodynamic hypothesis, the time may have come when otologists will not longer regard the hearing in the "chronic ear" as "written off." Much research and investigation still must be done before a standardized technic will crystallize. In only 4 of the series of patients mentioned has this hearing improvement been maintained. Despite cessation of discharge, a gradual heaping up of tissue in the hypotympanum once again has obliterated the round window region, and with this the hearing has returned to the preoperative level. Despite this meager result, it is my conviction that the day is not far off when with the concerted help of otologists all over the world a method will emerge which will effectually keep the hypotympanum clear. Otology is on the threshold of such events.

In carrying out operative procedures on infected ears one should have due regard to the function of the ear. The discharge, which is secondary, should remain secondary and be controlled. With the development of equipment and with that which today exists enabling the microsurgery of the tympanum to be executed under perfect visual control, one may say that one's first aim is that the ear shall hear.

The round window lies in a cul-de-sac surrounded by the following blind end extensions and protuberances: the sinus posterior tympani, the eminentia pyramidalis, the sinus tympani, the cavum tympani, the

subiculum promontorii, the sulcus promontorii, the fossula fenestrae cochleae and the cellulae tympanicae. Any infective condition of the middle ear may lead to partial or complete obliteration of this vital air space.

In acute otitis media, happily, adhesions are rare, and resolution leaves this air space intact—and hearing unimpaired. Not so the chronic conditions—chronic otitis media suppurativa, chronic otitis media non-suppurativa (chronic adhesive catarrh), osteitis, granulations, polypoid degeneration and cholesteatoma.

Radical mastoidectomy itself is largely instrumental in destruction of hearing. Operative trauma is followed by deposition of fibrous

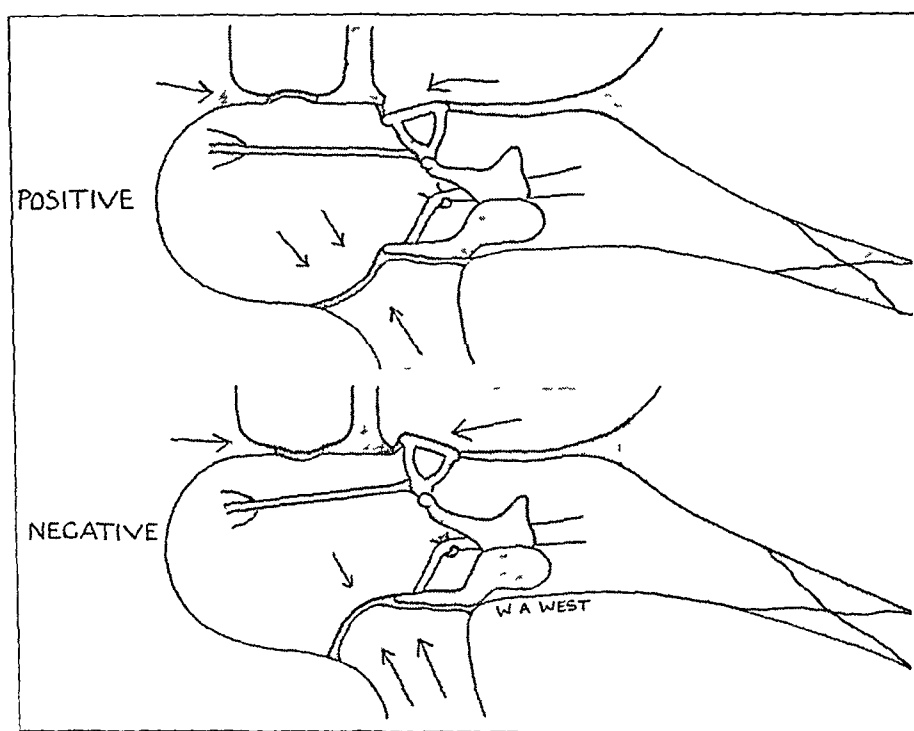


Fig 8—Mechanism of eustachian deafness. The dampening effects of positive and negative differences of pressure are shown. Positive pressure in the tympanum pushes the round window membrane inward, whereas negative pressure pulls it outward. In both cases dampening is produced, and the organ of hearing is thrown out of equilibrium, with resulting deafness. This accounts for the sensation of deafness experienced both in ascending and in descending in airplane travel, when air pressure in the middle ear is not in equilibrium with outside air pressure. The eustachian tube is closed.

tissue or granulations which obstruct the round window vestibule. In the conventional fenestration operation, radical mastoidectomy is the preliminary step. When a hearing gain is not maintained after fenestration despite a positive fistular sign and an open fenestra, I am convinced that the obstruction to sound transmission is fibrous or granulation tissue deposited in the round window cul-de-sac. The surgeon has

relieved the stapedial deafness and has created hypotympanic deafness. This area must, therefore, be treated with the greatest respect in the conventional fenestration operation in which mastoidectomy precedes the actual fenestration stage.

In transtympanic fenestration such interference of the hypotympanum does not arise. The transtympanic operation is entirely supratympanic, and the mastoid is untouched. To restore hearing in cases of hypotympanic deafness the piece of tissue, fibrous, polypoid or granulated, or the thickened drum that forms the barrier at the round window must be removed.

Hypotympanic deafness may be defined as a condition in which sound of normal amplitude or intensity is incapable of penetrating this barrier to excite the perilymph adequately to elicit a cochlear response.

If the thick mechanical barrier to hearing could be removed and replaced by thin epithelium, then it might be claimed that another vast group of persons suffering from deafness has been brought within the orbit of operative relief. In the war on deafness, this must be the next objective. Its conquest may be hastened by transtympanic surgery.

Prof. George von Békésy, research lecturer at Harvard University, director of the Institute of Experimental Physics, Budapest, Hungary, gave guidance and help in the drafting of this paper, and Prof. M. H. Lurie, of Harvard University, contributed sound advice.

Fifth Floor, Lister Building

# TRANSTYMPANIC APPROACH AND FENESTRATION

## II The Current Technic

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**T**HIS WORK was first published some two years ago in Great Britain and South Africa. Since then the transtympanic approach has been accepted and adopted in various overseas centers. This paper will endeavor to present in detail some refinements of technic. Needless to say, in any progressive science nothing is really final, and further refinements are sure to be incorporated as and when an ever larger number of surgeons perform this logical procedure. It becomes, however, increasingly necessary once more to state clearly the objectives and the scope of the transtympanic approach.

The transtympanic approach has nothing whatsoever to do with fenestration. Fenestration happens to be a procedure for which this approach is eminently suitable. As will be shown later in this address, the transtympanic approach is ideal for the performance of an atticotomy when the mastoid process is sclerotic and the infection is confined to the atticantrotympanic region, as an alternative procedure to the radical mastoidectomy, endaural or postaural.

The Lempert fenestra nov-ovalis operation consists of two classic procedures, the Lempert endaural mastoidectomy and, superimposed on it, the Lempert fenestration.

Transtympanic fenestration is also a dual procedure—the transtympanic approach followed by the Lempert fenestration.

The Lempert endaural mastoidectomy is the ideal operation for chronic mastoiditis plus attic suppuration.

The transtympanic approach would supply perfect drainage of the atticantrotympanic region only and is indicated when the mastoid process is sclerosed but uninfected.

Douglas C. Carruthers, of Sydney, Australia, who has considerable experience both of the endaural and of the transtympanic operation states:

I am attracted to the transtympanic method because of its simplicity and because the access obtained is so much more direct than any other approach. With regard to the results of fenestration where this approach is used, an

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From the Department of Surgery, University of the Witwatersrand

Read before the Section on Laryngology, Otology and Rhinology of the American Medical Association, Chicago, June 23, 1948

improvement of hearing comparable with that of any other method can be achieved by the transtympanic approach. I would stipulate, however, that much as one may have operated by other methods, an attempt at a new approach is not always easy. Just as otologic surgeons have had to prepare themselves for the endaural method by assiduous and oft repeated cadaver practice, so they must do this again before it is reasonable to expect that they will correctly assess the new method. The surgeon who will just try the transtympanic approach once or twice, and be turned back by its little difficulties rather than master them, will, I am sure, deprive himself of much of the pleasure which comes of being able to orientate oneself to a new surgical environment. I still operate by both Lempert's and Popper's approach, and I have many technical points which are my own. I am not prepared to say yet that one method is entirely better than the other. The main significance of Dr Popper's work, as I see it, is that he has devised a simple and practicable anterior transmeatal approach to the posterior portion of the tympanum, the aditus and the vestibulo-ampullary area. As such, I am sure that it will be of lasting use in otologic surgery.<sup>1</sup>

Only after assiduous cadaver practice will the surgeon be capable of deciding this issue for himself. Revisions are difficult with this approach, and the Lempert procedure is recommended. When fenestration is to be performed in the presence of a sclerotic mastoid process or an abnormal lateral sinus, the transtympanic approach seems the method of choice.

The transtympanic approach was devised some five years ago. The objective was to provide the more direct, as well as the widest, exposure of the attic region, aditus and antrum. When one goes over in one's mind what constitutes the main indication for radical mastoidectomy, it seems fair to say that the answer is chronic supuration of the attic. Another observation that cannot have escaped any one is that most chronically discharging ears, probably 90 per cent, exhibit dense sclerosis of the mastoid process on roentgen examination. This deposition of bone is nature's method of reacting to an infective process—her attempt to prevent its extension. Why, then, when the infection is limited to the attic space, does the surgeon as a matter of routine reopen the sclerotic mastoid? The reason is that he is required to create a tunnel which will lead to the attic—or, in other words, he does a radical mastoidectomy, either modified or varied to suit his individual taste, in order to make the attic space communicate with the external auditory meatus. The bone thus exposed is prone to a low grade reinfection, and although the surgeon has drained the

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<sup>1</sup> The Lempert technic gives magnificent exposure as well as entry and maneuvering space, and no surgeon not thoroughly familiar with this technic should attempt the transtympanic approach with its new orientation and environment. With proper equipment, experienced surgeons will have not the slightest difficulty in carrying out the less traumatic transtympanic operation for adequate exposure of the attic, the antrum and the site of fenestration, but entry and maneuvering space are admittedly not so wide. This is not too high a price to pay to preserve the mastoid process.

suppurative focus in the attic, he is too frequently faced with a troublesome and often stubborn postoperative otorrhea

To be able to gain wide exposure of this region without traversing the mastoid process seems imperative, and this is amply achieved by the transtympanic approach. Needless to say, when the mastoid process is not sclerotic, mere drainage of the attic is insufficient, and it may be necessary to do a postaural or an endaural exenteration of the infected mastoid cells in addition to the drainage of the epitympanum or attic.

The great virtue of the transtympanic operation is the preservation of the skin of the meatus. The meatus is the corridor already beautifully lined with skin, which remains undisturbed.

The advantages of the transtympanic approach whether used for drainage of the atticocanal region or for fenestration may be briefly summarized: 1. It is a direct frontal attack on the atticocanal region—the ideal fenestration site. 2. The mastoid process is untouched. 3. The site of fenestration lies square on, and by working from this anterior point of vantage a larger fenestration can be achieved. 4. The membranous labyrinth is seen to better advantage through the operating microscope. 5. Trauma and postoperative otorrhea are minimal. 6. The field is bloodless. 7. The operating time is reduced. 8. The tympanomeatal flap is fashioned right at the outset of the operation, before any burrs are used and bone dust and particles created. The flap is immediately tucked away safely under the ledge of the tympanic plate. Its osteal surface is covered with a protective piece of gutta-percha, and the entire space under the ledge of the tympanic plate is packed off with cotton wool pellets. The flap can then be forgotten, safe from trauma and fouling by bone dust to the end of the operation.

The fact that this flap can be fashioned so easily and within a few minutes has evoked much favorable comment. This feature alone, it is claimed, would determine the permanent position of the transtympanic approach in operative otology. It might be useful to mention at this juncture that the tympanomeatal flap can be fashioned in any way the surgeon desires. In the fenestration procedure it must hinge from the annulus tympanicus at the upper border of the tympanic membrane. In atticocanostomy it should preferably hinge from an outer portion of the canal. This flexibility will be greatly appreciated by surgeons familiar with this type of surgery. Using the transtympanic approach, one does not find it necessary to remove the head of the malleus, and reports from other workers, including Shambaugh, Juers, Tato and Lund, have confirmed that postoperative results are thereby in no way prejudiced.

#### POSITION OF THE PATIENT

Custom dies hard. For over half a century every aural surgeon has been taught to approach any structure of the ear through the mastoid process and, accordingly, he operates from the back. It is not sur-

prising, therefore, that many surgeons have attempted to do the transtympanic operation from the back despite explicit instructions to the contrary. I have heard numerous protests that the large exposure of attic and clear landmarks that I described were unattainable and that the operation was found most difficult and access restricted. In the case of every single one of these protests it transpired that the surgeon attempted this operation by standing behind the patient in the conventional manner. It must, therefore, again be repeated and emphasized that the surgeon operates from the front, the patient faces him with the ear to be operated on uppermost, and it is essential that these relative positions of the patient and the surgeon be maintained from start to finish. The *raison d'être* of the transtympanic operation is that it is a frontal attack. It is impossible to carry out this technic from the back.

#### ILLUMINATION STEREOSCOPY AND MAGNIFICATION

In a previous publication the importance of stereoscopic illumination and of magnification was stressed, and it was explained why competent headgear incorporating perfect beam illumination and stereoscopy, and adequate magnification, was so essential. With the wider exposure in this final technic the conventional Lempert equipment may be used. I nevertheless favor the prismatic headgear.<sup>2</sup> The advantage of having an intense beam of light near the same plane as the optical axes must be experienced to be appreciated.<sup>3</sup>

#### CASE RESULTS

With every improvement in technic the improvement in the results to date has been most striking. Simson-Hall recorded that of a series of 200 cases, only half were suitable for analysis. This has also been my experience in a smaller number of cases. Changes of technic,

2 Popper, O. Fenestration of Labyrinth. II. Transtympanic Fenestration, *J. Laryng. & Otol.* **61** 441-458 (Aug.) 1946.

3 During a recent visit to the United States at the invitation of the American Medical Association the author had lengthy conferences with leading manufacturers of optical equipment. When this headgear eventually becomes available, the features stressed will be incorporated, that is, light beam near the optical axis, very short interpupillary distance at the objective surfaces of the prisms insuring constant and perfect stereoscopy, two stage magnification from 1.5 to 2 up to 3 and 3.5. The surgeon will wear this headgear from beginning to end of operation without interchanging and will be able to use one or other of the magnifications at any stage of the operation by moving a sterilized lever. This headgear would be equally useful to ophthalmic surgeons. A working distance of between 9 and 11 inches (23 and 28 cm.) using the Galilean system of magnification is the aim. The makers will supply this headgear in a suitable case with a sturdy lock. Correction for the surgeon's error of refraction will be incorporated, so that he will not be required to wear spectacles. This banishes the nuisance of fogging.



inadequate follow-up (a great handicap in a large country such as South Africa, where huge distances separate sparsely populated communities), poor selection, inadequate equipment, cases early in the series and cases too recent for appraisal account for the omissions which reduce the number to less than half. Fenestration has restored hearing to or above the 30 decibel level, with hearing gains of from 12 to 25 decibels

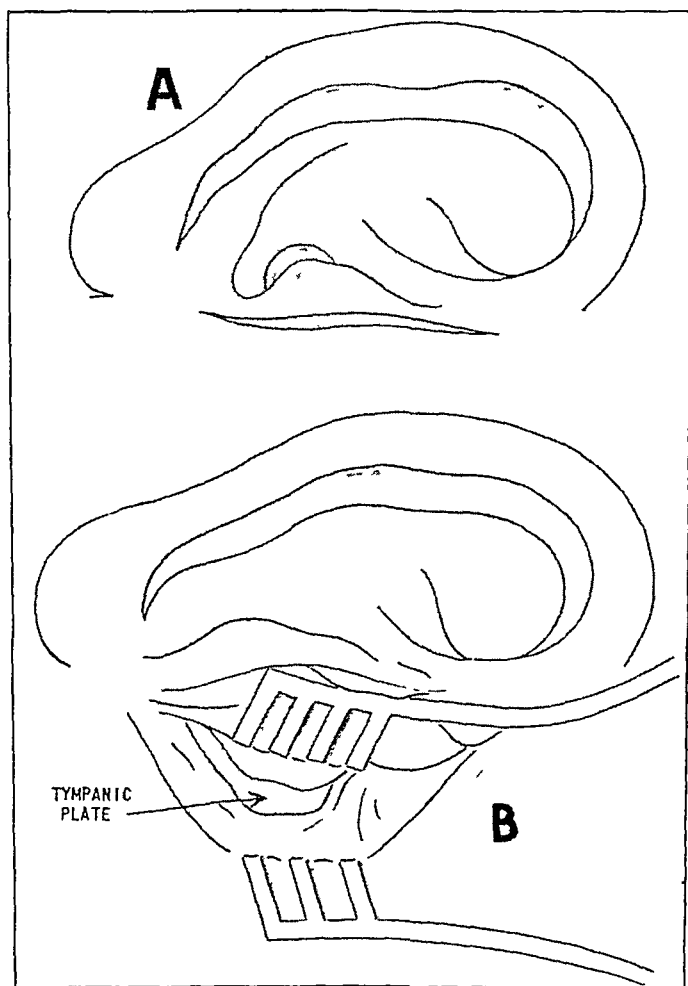


Fig 1—Stage 1. In *A* an excursion is made into the fascial plane of the temporomandibular fossa. In *B* the tympanic plate is exposed.

for the frequencies 512, 1,024 and 2,048 cycles per second in 74 per cent of cases which would be regarded as of class A. This improvement has been maintained on an average for about one year, and a review at a later period will demonstrate whether or not the result is permanent. In other cases in this series there was recorded a gain of less than 10 decibels, and this did not bring the hearing level to the 30 decibel line. In still other cases, with hearing gains in some instances of 30 or more

decibels, the improvement was lost, and the hearing sank to the pre-operative level. In all cases the audiograms were made in an external center. I am aware that this record may not be impressive when

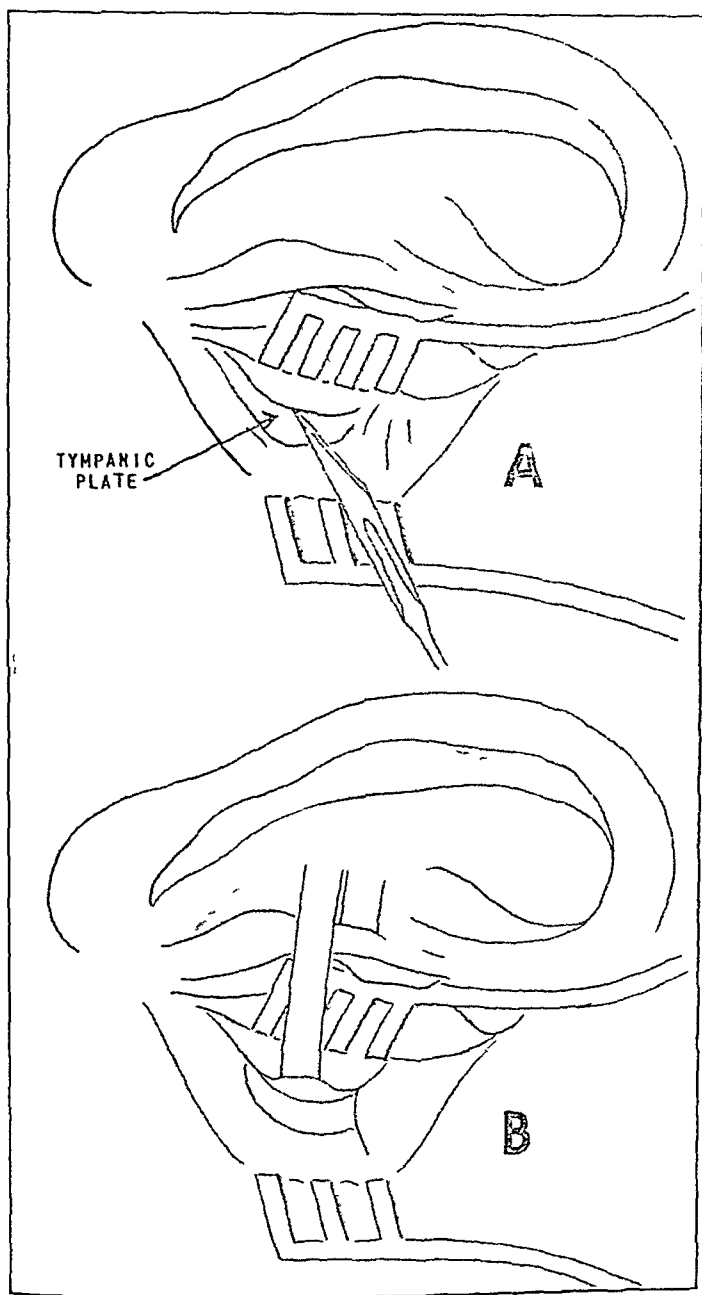


Fig 2—Stage 2 In *A* the inferior and superior edge of the meatal cartilage is being detached. In *B* the free edge of the cartilage is being everted.

compared with some that have been published, and it is my hope that with more experience and many other surgeons now using the transtympanic approach, those records of achievement will be equaled. In

one case hearing was destroyed because of detachment of the flap. In another the facial nerve was injured. In this case the fenestration was too near the facial canal and had encroached on the upper surface

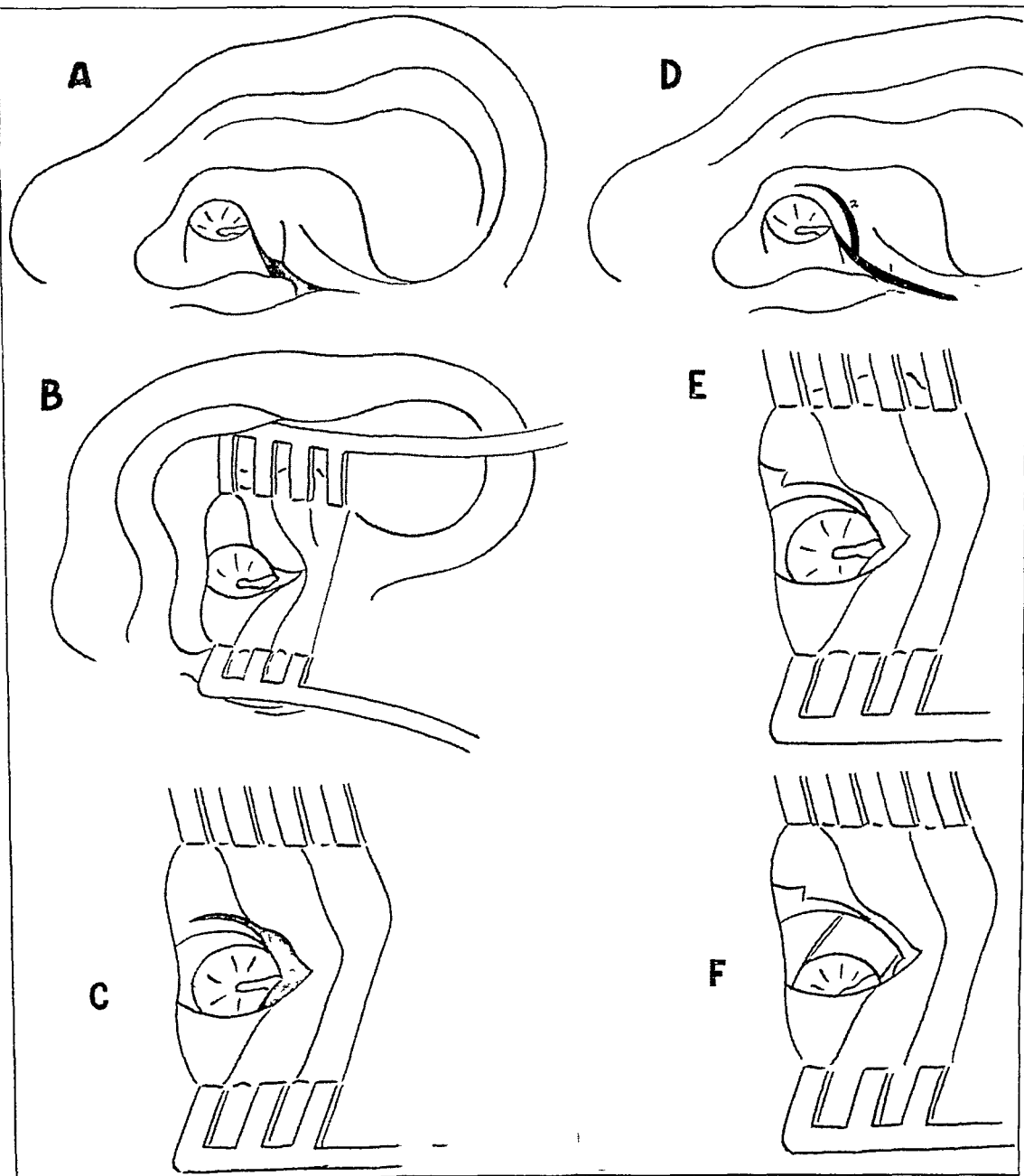


Fig 3—The alternative endaural incision *A*, first incision at 12 o'clock, *B*, retraction, *C*, second incision made during retraction, *D*, both incisions undistorted (without retraction), *E*, posterior L flap and anterior flap retracted to expose the bony meatus, the mastoid cortex and the root of the zygoma *F*, same as above plus tympanomeatal flap incisions

of the canal, tearing the blood vessel which is constantly found at this level of the canal. When one is performing fenestration, all such hazards must be kept in mind, and although the final technic virtually

banishes them, the patient must in every instance be fully enlightened. It is my practice to explain these hazards in detail to the patient and to insist on his signing a statement that the hazards have been explained to him and that he has understood them.

The technic about to be described is practiced with great success notably by Lund and Aubry, whose statistics of successful results in class A cases compare favorably with results elsewhere. They have to their credit a very much larger number of cases than it would be possible to collect and present in a country with such a small population as South Africa, and it is on the results of such overseas workers rather than on my own work that the final evaluation of the transtympanic operation will rest.

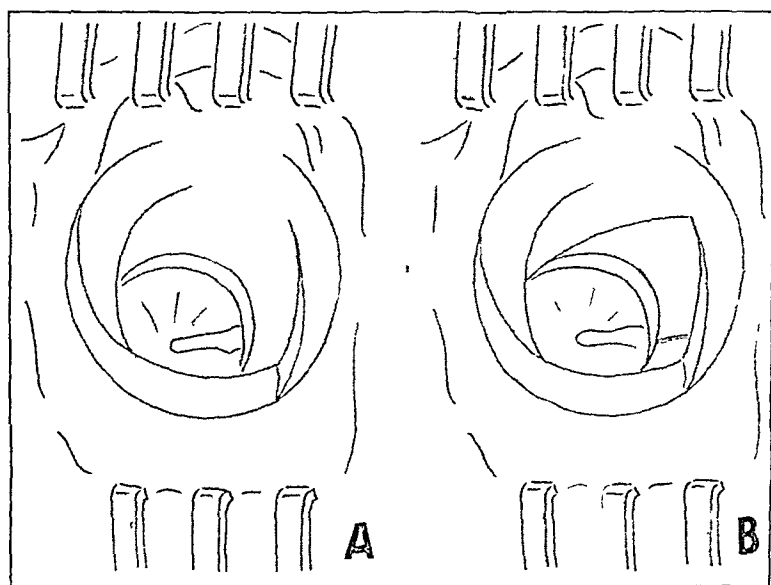


Fig 4—Stage 3. In *A* the tympanic membrane is seen lying at the bottom of the external auditory meatus. In *B* the tympanomeatal flap is mapped out.

#### ANESTHESIA

Any of the conventional methods of inducing local or general anesthesia may be employed. In the case of the latter, however, the anesthetist is to be instructed to avoid congestion. The choice of anesthetic is therefore largely a matter of the surgeon's preference. I have operated recently in South America with the patient under local anesthesia and found it entirely adequate.

#### PREPARATION OF PATIENT

It is preferable to admit the patient to the hospital at least thirty-six hours before the operation, and one may administer sulfadiazine during this period. The ear to be operated on is prepared in the usual way. The position of the patient has been stressed; the surgeon operates from the front with the patient's face directed toward him. If, therefore, the right ear is to be operated on, the head rests on the left side, preferably inclined somewhat downward.

## THE FINAL TECHNIC

**STAGE 1—*The Temporomandibular Fossa Is Entered and the Tympanic Plate Exposed***—In the first stage of this operation one makes an excursion into the temporomandibular fossa in the fascial plane immediately contiguous with the cartilage of the tragus and of the external auditory meatus. This area is infiltrated with a 1 per cent procaine hydrochloride solution containing 8 drops of epinephrine hydrochloride solution to the ounce. The first puncture is made about 1 cm in front of the tragus, the point of the needle being directed backward toward the cartilage of the tragus but only up to and not through the cartilage. The needle is withdrawn slightly and the fluid injected. By directing the needle through this one puncture upward, downward and inward and continuing the injection at each stage, this entire space is infiltrated. By careful manipulation, hugging the cartilage, one is generally able to get the point of the needle onto the tympanic plate, where further infiltration proceeds.

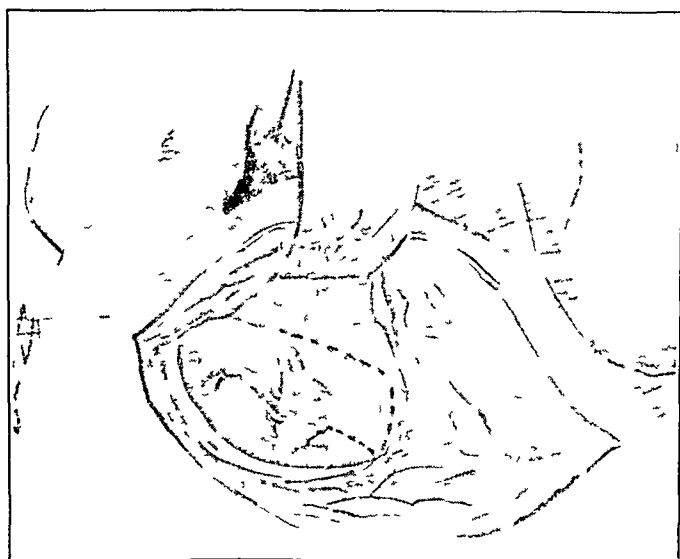


Fig 5—Realistic illustration of the outlining of the tympanomeatal flap

It might be mentioned at this stage that the temporomandibular articulation is remote and that throughout this operation there is not the slightest risk of injuring it. Not a single symptom referable to this region has been encountered in over 100 cases. The articulation is 13 mm from the external auditory meatus! The first stage of this operation is illustrated in figure 1.

An incision running from the lobule to the helix approximately 1 cm in front of the tragus and about 3 cm in length is made, with the blade of the knife being directed toward the cartilage of the tragus. The blade must not go through the cartilage, it must go only up to it. The edges of the incision are separated with an ordinary mastoid retractor, and bleeding points are secured. This first stage embraces exposure of the tympanic plate. The cartilage of the tragus is defined in the posterior part of the field now exposed and, with the blunt handle of the knife, cleared as far down as the tympanic plate. Occasionally, small fibers anchoring the perichondrium to the overlying fascia are snipped with ophthalmic scissors. It will be noted that a sharp angle is present in the cartilage of the tragus where it dips backward to become the cartilage of the

external auditory meatus. When this region has been cleared, it is advisable to remove the retractor and reinsert it so that the blades engage below this angulation. Again careful blunt dissection is carried out toward the meatal cartilage in all directions, that is to say, from below upward and also superiorly where the tongue of meatal cartilage becomes attached to the superior bony wall of the meatus. The latter point is of great importance. It is one of the modifications in this new technic to detach the meatal cartilage both from the tympanic plate and from its attachment to the superior bony meatus. This insures the eventual magnificent exposure of the tympanic field. Blunt dissection is proceeded with until the edge of the tympanic plate is felt on the dissector or a probe. The dissector sweeps from below upward and from before backward so as to free the entire meatal cartilage. After removing and reinserting the retractor somewhat deeper, the entire tympanic plate is exposed to view and the first stage of the operation has been completed.

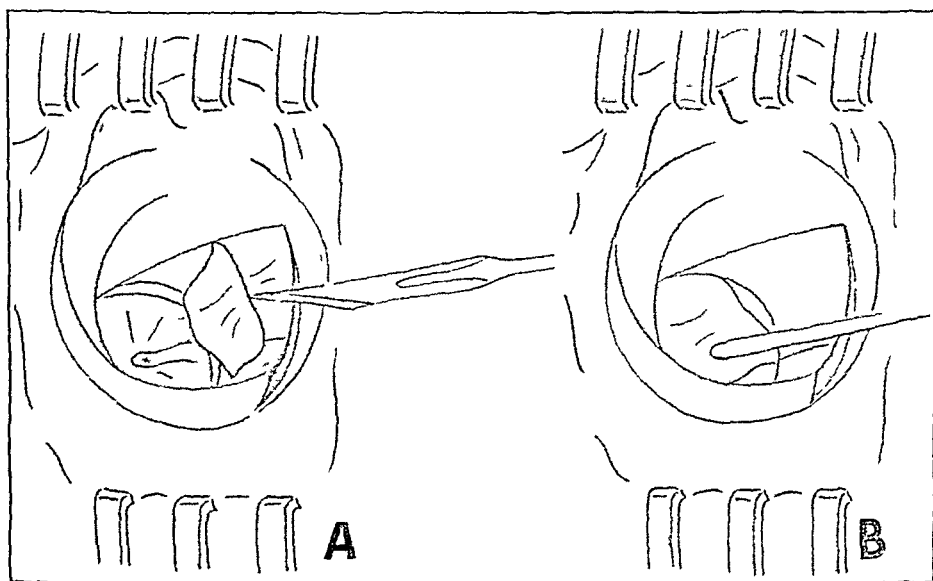


Fig 6—Stage 4. The tympanomeatal flap is reflected and safely stowed under the ledge of the tympanic plate. (The diagrammatic illustration of stage 4 is continued in figure 9.)

If careful and gentle manipulation is used, there will be no bleeding. It is important not to dissect anterior to the tympanic plate more than is absolutely necessary for its exposure, as in this region small veins may be encountered which may prove troublesome. Should this happen, a tiny strip of ribbon gauze soaked with a solution of epinephrine hydrochloride or with thrombin will control it instantly. It is advisable in that circumstance to anchor such a swab suitably, otherwise the swab is almost certain to be forgotten at the end of the operation.

The first stage of this operation is easy. With care and proper infiltration, it is bloodless. It is essential to clear the entire meatal cartilage both anteriorly down to the tympanic plate and superiorly to its attachment to the bony meatus.

**STAGE 2—The Meatal Cartilage Is Detached and the Bony Meatus and the Tympanic Membrane Are Exposed (fig 2)**—In this stage the meatal cartilage is carefully separated from its attachments, medially and superiorly. The cartilage is attached to the posterior edge of the tympanic plate. With a sharp-pointed

scalpel it is detached from below upward in a bevel-like manner. Note that the term "detached" is used, indicating that the cartilage is not incised. From the upper point of this detachment, the knife is swept outward to detach the meatal cartilage from the superior portion of the bony meatus<sup>4</sup>. Another point to be observed is that the knife must not cut the opposite side or the skin that is on the posterior portion of the auditory meatus. The tip must be allowed only to just perforate. The incision that detaches the cartilaginous tongue is therefore somewhat L shaped. The next maneuver in this stage is a major point in the final technic which makes the wide exposure of the next stage possible. The retractor is removed. A piece of gauze is inserted into the meatus and identified with a Killian speculum in the gap between the now free cartilage and the edge of the tympanic plate and bony meatus. The gauze is then drawn out from below upward through this gap, and the free edge is thus everted between the slings of this gauze and pulled outward and backward. The retractor is now reinserted in the following manner. The everted edge of the meatal

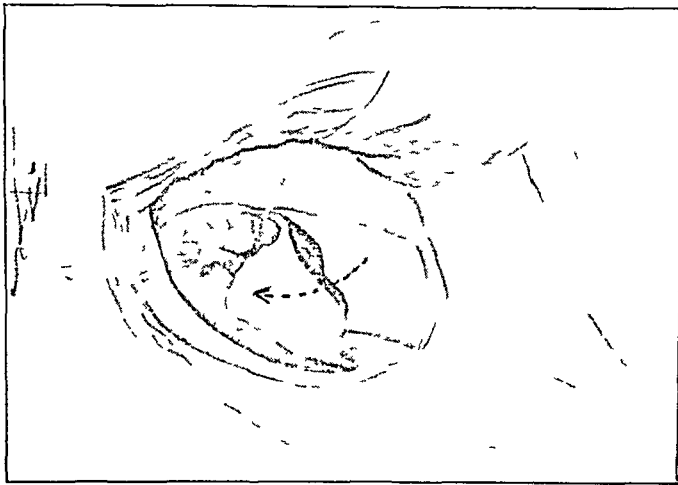


Fig 7—Realistic illustration of the reflection of the flap

cartilage is engaged in the jaws of the retractor, and the latter is opened up. The tympanic membrane and the bony portion of the external auditory meatus are clearly and widely exposed<sup>4a</sup>.

4 An endaural incision of the skin down to bone of the bony meatus at 12 o'clock assists in accurate separation.

4a An almost equally wide exposure can be achieved by an endaural incision running from 12 o'clock at the superior edge of the tympanic plate within the meatus outward to a point in front of the anterior convexity of the helix between the latter and the tragus, and a second incision across the superior bony meatus (fig 3). The soft tissues are retracted. Possible objections are (1) The circumferential integrity of the external auditory meatus is destroyed, (2) as the external auditory meatus is not widened at the expense of the mastoid process posteriorly in the transtympanic procedure, postoperative meatal stenosis would therefore be more serious than if mastoidectomy had been done, (3) alterations of shape in the cavity of the meatus may lead to disturbances of resonance within this cavity, (4) the antetragal incision is easier, gives better exposure and avoids the massive displacement of soft tissues necessary with the endaural incision.

The transtympanic approach was originally performed through an endaural incision, but the antetragal exposure described was considered to be superior. The cosmetic result is superb. The linear incision line is generally invisible at the end of the first week. However, many surgeons perform the transtympanic operation with an endaural incision and presumably consider that incision superior.

It, after retraction, it is found that the bony meatus is so narrow that only the posterior portion of the tympanic membrane is visible and the handle of the malleus is hidden by the projecting edge of the tympanic plate, the latter may be taken down. This is rarely necessary.

**Method** The skin from the anterior surface of the tympanic plate is reflected backward, and with a small-bladed, goose-necked rongeur the protuberant portion

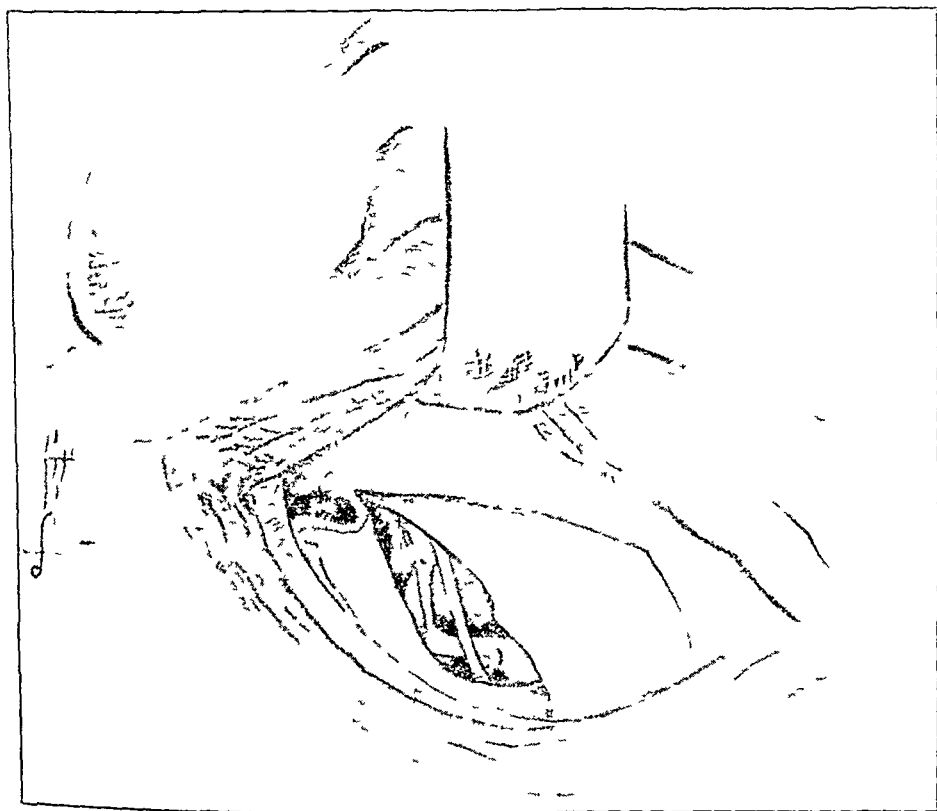


Fig 8—Realistic illustration of the exposure of the notch of Rivinus, the sulcus tympanicus and the tympanic contents (the long process of the incus, the chorda tympani, the stapedial tendon, the eminentia pyramidalis, the upper edge of the fossula of the round window)

of the tympanic plate is nibbled down. The skin is then applied to this surface. It will be found that little removal is necessary to expose the handle of the malleus to view.

**STAGE 3—The Tympanomeatal Flap Is Mapped Out** (figs 4 and 5)—When the retractor has been spread, the next landmark is beautifully presented. It is the tympanic membrane, lying squarely at the bottom of the auditory meatus. The tympanomeatal flap must now be mapped out. If the purpose is to proceed from this operation to fenestration, then obviously the flap must hinge at the upper edge of the tympanic membrane as illustrated in figure 5.



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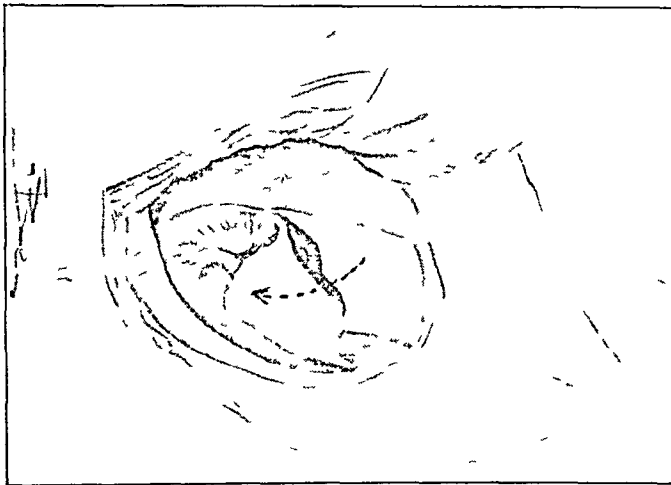


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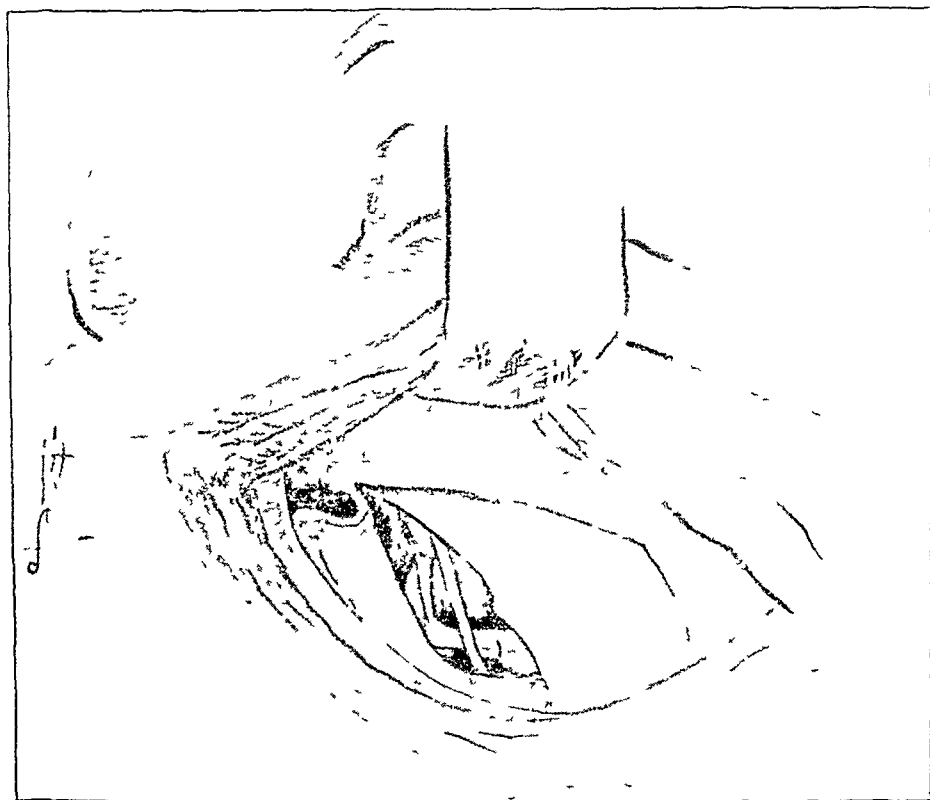


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If, however, an atticoantrostomy is being done, for which the transtympanic approach provides excellent exposure, the flap must hinge from the outer or opposite end and be detached from the sulcus tympanicus

**Mapping of the Flap for Fenestration** It is unnecessary to infiltrate the integument prior to making the incisions for the flap. Indeed, it is inadvisable to do so, as no bleeding is encountered. Infiltration tends to macerate and devitalize the thin skin encountered in this region. A plug of cotton wool soaked in epinephrine solution U S P is gently packed into this region and left in situ for about one minute. The upper incision should not be too far away, always consistent of course with sufficient length to afford adequate cover for the eventual fenestra. This incision, therefore, is made to sweep across the auditory meatus from before backward to encircle approximately the upper half of the bony meatus. The incision is made down to bone with a sharp-pointed, small-bladed scalpel. The distance of this incision from the tympanic membrane is about 15 mm, or at the superior and outer edge of the tympanic

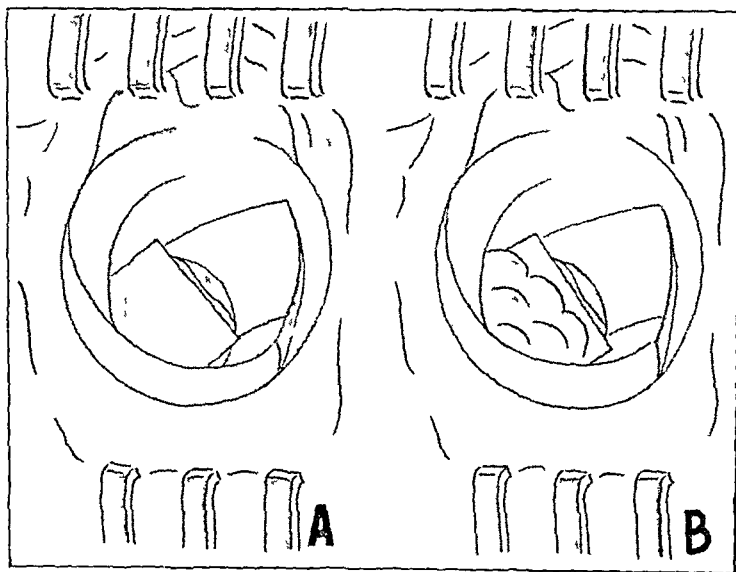


Fig 9—Stage 4 continued. To protect the flap from injury and fouling by bone dust, rubber tissue (A) and cotton wool pellets (B) are packed over it.

plate. After the cotton wool plug soaked with epinephrine solution U S P has been removed, the next two incisions, which complete the flap, are made.

**Anterior Incision.** The handle of the malleus is identified and serves as a guide for the direction of this incision. The incision is made in line with the handle from the edge of the tympanic membrane at the sulcus tympanicus and runs outward to meet the upper or outer incision already described.

**Posterior Incision.** This runs parallel to the anterior incision and at a tangent to the posterior curve of the drum and outward to meet the outer or upper incision. Needless to say, both anterior and posterior incisions are down to bone. No doubt many surgeons practicing this technic have their own particular preferences and may modify this procedure according to their taste. The main point, however, is that in this region the skin is beautifully thin and pliable and requires no subsequent thinning down or other manipulation. It may be added that stages 1, 2 and 3 take longer to describe than to execute, but rigid attention to detail is imperative. The instrumentation is extremely simple,

and ordinary ophthalmic gear has been found most suitable. The ophthalmic forceps, curet and scissors and scoop are most useful. They are short, slender and delicate.

**STAGE 4**—*The Tympanomeatal Flap Is Reflected and Stowed Safely Where It Is Protected from Injury and Fouling by Bone Dust* (figs 6 to 8)—With a sharp-bladed knife, occasionally assisted by an ophthalmic curet and ophthalmic scissors, and dental pellets, the skin bounded by the incisions is now reflected from its bony bed. A sharp-bladed knife is used to evert the upper or outer edge. The blade of this knife is directed toward the bone. Owing to a suture in the temporal bone in this region, one often finds anchoring fibers firmly holding the skin down, and blunt dissection might result in tearing. By using an ophthalmic curet gently and occasionally small pellets of cotton wool soaked in epinephrine solution U S P, such fibers are easily exposed and snipped through with ophthalmic scissors. The skin is folded over as reflection proceeds right

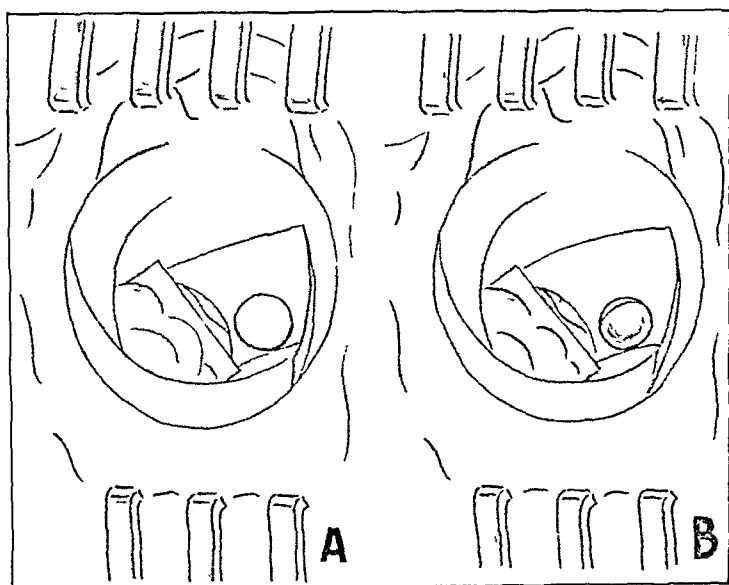


Fig 10—Stage 5. A perforation is made into the attic space. (The diagrammatic illustration of stage 5 is continued in figure 13.)

down to the sulcus tympanicus. At this point, an obturator membrane, the lining membrane of the middle ear, attaches the annulus tympanicus to the sulcus tympanicus. With a Lempert small-bladed separator this membrane is detached and the notch of Rivinus and the lower edge of the sulcus tympanicus exposed. Through this gap the chorda tympani will already have been seen, as well as the long process of the incus and the stapedial tendon, the eminentia pyramidalis and the upper edge of the fossula of the round window. The flap is now carefully folded over the upper part of the tympanic membrane with which it is continuous. It is now tucked underneath the ledge of the tympanic plate. To protect this flap further, a small piece of rubber tissue is placed over it, and, for good measure, on top of the rubber tissue small pellets of cotton wool are packed. These pellets are moistened and gently compressed, so as not to tear the underlying membrane, and the whole tympanic space below the sulcus is thus hidden. The flap is now safely stowed and forgotten until the very end of this operation. This fourth stage of the operation occupies but a few

minutes and presents no difficulties whatsoever From now onward the entire procedure is supratympanic

**STAGE 5—The Outer Attic Wall Is Removed** (figs 10 to 13) —Professor Tato, of Buenos Aires, Argentina, performs this stage of the operation with very small chisels and a small mallet, swiftly and unerringly My own preference is to use a diamond drill to perforate the outer attic wall at a point where the sulcus tympanicus and the edge of the anterior incision form an angle

**Instruments** The cable arm dental machine seems more efficient and flexible than the belt-driven type A belt must be covered by sterile cloths, chafing and wear are excessive The speed of the belt type machine is lower than that of the cable-driven type Diamond burrs operate best at high speeds The cut can be controlled to the minutest fraction of a millimeter at such speeds Some workers assert that the vibration of the cable type machine disturbs them Such vibrations do not occur in the better class equipment even when this is operat-

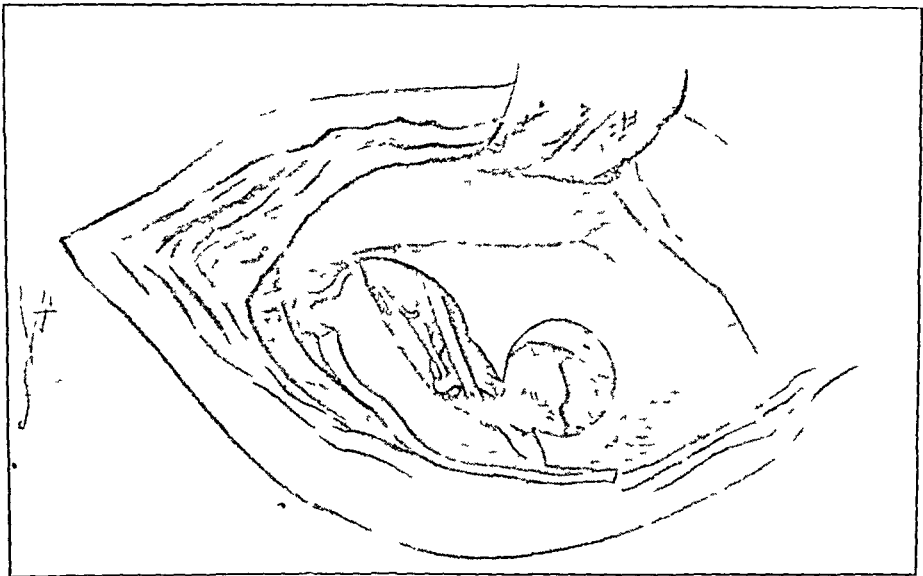


Fig 11—Realistic illustration of the perforation of the attic wall This and figures 12 and 16 show the flap unprotected so as to emphasize its relationship Note the crura of the stapes

ing at the highest speeds To be able to clean the cable arm with rectified spirit and then to enclose the whole length of it in a sterile sausage of linen gives one a feeling of comforting tranquility in the operating theater An operating speed of over 3,000 revolutions per minute is desirable when one is using diamond burrs It must be remembered that a cable arm has a spring wrist at its end and that this should not be flexed unduly The engine, therefore, should be suspended in the direction of the head of the patient and at such distance and such height that the contra-angle hand piece, presently to be described, is always in line with the cable arm of the engine Should the wrist spring be damaged during the operation, it can be replaced by a spare wrist which, of course, is always available in a matter of seconds The standard dental contra-angle hand piece is certain to win approval Surgeons accustomed to this advanced form of operative work will find that the short contra-angle hand piece affords much better visual control The contra-angle hand piece

should be of the slip-on joint type and the corresponding fitting on the cable arm of the dental machine must be selected. This is standard equipment which can be supplied from the stock of any dental depot. Standard long dental diamond burrs are used. Long burrs are not designed to be used with the contra-angle hand piece, the ends of these burr shafts have to be specially flattened and grooved to fit the instrument. Any dental mechanic is able to do this in a few minutes. The length of these burrs must be sufficient to reach the field. A sleeve or bushing to prevent "whip" is also special equipment. It is best to assume that the instrumentation of this work is not common knowledge and to describe what is used in detail. No apology is needed, therefore, for this lengthy digression. Only four types of diamond burrs are used—a cylinder, a sphere, a disk and a cone. The diamond burr may be described as a perfect surgical instrument. Its cut can be controlled within the smallest fraction of a millimeter, it never wears out, no pressure is needed—in fact, is undesirable, it fragments the endosteum so that portions of the endosteal membrane come away

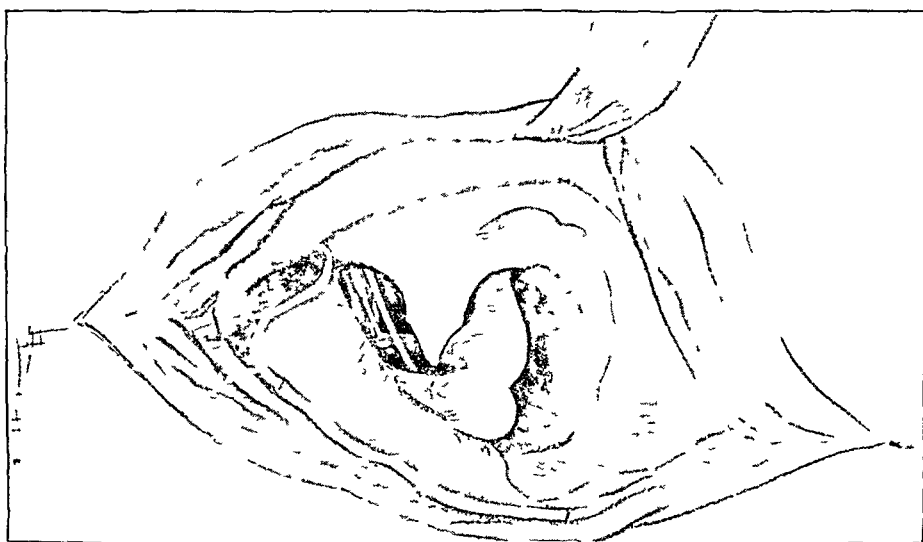


Fig 12—Realistic illustration of the removal of the attic wall

with such fragments and the fistula requires a minimal amount of intervention to remove endosteal membrane.<sup>5</sup>

With the diamond cylinder placed in the angle formed between the sulcus tympanicus and the anterior incision of the flap, the next step is to drill an opening into the attic. The end of the diamond burr is placed at this location. The foot switch operating the dental machine is depressed and a socket formed in the outer attic wall. The foot switch is released, the field is flooded and irrigated with a penicillin solution, and aspiration is carried on until every vestige of bone dust is removed. Under no circumstances whatsoever may a rotating burr be introduced or removed from the field while it is in motion, and the

<sup>5</sup> The diamond burrs referred to are made for me by the B L Dental Corporation, Long Island, N Y (cylinder nos 225 and 232, sphere nos 223 and 226, disk no 236, and cone no 229). I am in touch with this firm to supply this equipment already modified to fit contra-angle hand pieces, and these diamond burrs should be available by the time this paper is published. The shafts are  $2\frac{1}{4}$  inches (about 6 cm) long.

surgeon should practice until this sequence of placing the burr, depressing the switch, releasing the switch, and removing the stationary burr becomes a reflex. This reflex is swiftly acquired and will banish mental strain. The diamond cylinder is replaced in the socket it has created and allowed to rotate at maximum speed for ten seconds without any but the gentlest pressure being used. Again the field is cleansed after withdrawal of the burr, and this process is repeated until the attic is perforated. The surgeon feels a slight "give" as the tip of the diamond cylinder sinks into the attic space, and, as only the slightest pressure has been used, there is not the remotest danger of any injury being done to the attic structures. After the field has been thoroughly cleansed, the body of the incus will be visible through the perforation.

The smallest size Lempert curet (0000) is now introduced into this opening, and, with the scoop facing the surgeon, the bony bridge between this opening

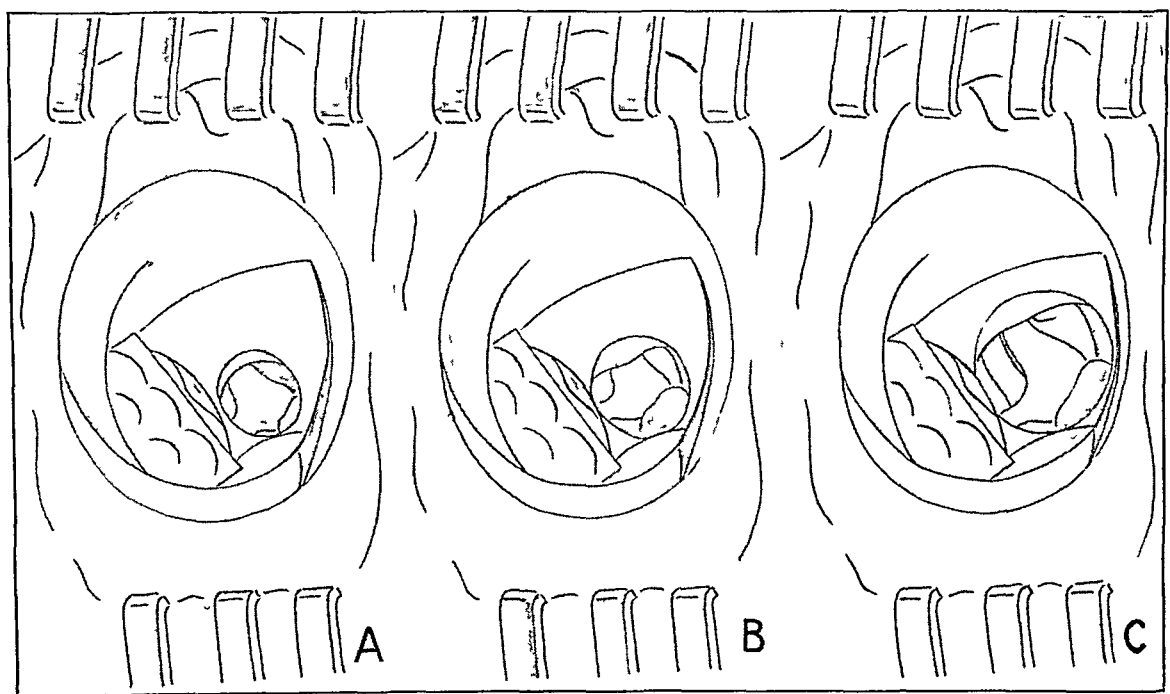


Fig 13—Stage 5 continued. In *A*, after perforation of the attic wall, the body of the incus is exposed and the incudomalleolar articulation becomes visible. In *B* the opening is enlarged, and the upper part of the fenestration site is visible. In *C* the entire incus is exposed, with the facial nerve appearing below the short process of the incus.

and the free lower edge of the attic wall is fractured outward. The curet is reinserted, and this procedure is repeated until the entire incus is exposed, the bone being fractured outward in every case. Not only will the entire incus now be visible, but also its articulation with the head of the malleus. After gross removal of bone with the Lempert curet, the disk diamond burr is used to open the attic as widely as possible right up to the tegmen and backward to the aditus ad antrum, so that this entire region is completely exposed to view. Previous difficulties and stenoses were due to failure to adopt this wide exposure. With the diamond disk burr it is possible to use three surfaces, the flat end, the rim and the upper surface. The edge of this burr is hooked under any projection which is to be cleared, one gently pulls the instrument outward, using the upper

diamond surface and working away from the tympanic structures. The burr is removed approximately every ten seconds to minimize the generation of heat, and the field is cleansed as has already been described. With the incus still in position, the ampullated end of the lateral canal or "dome" can be seen in the upper region of the field above it, the facial nerve below the short process and the chorda tympani crossing its long process.

In otosclerosis the incus has no function, and in fenestration its removal is necessary for exposure of the fenestration site.

*Prevention of Permanent Deafness Following Removal of the Incus in Mastoidectomy*—Almost every otologist must have made the observa-

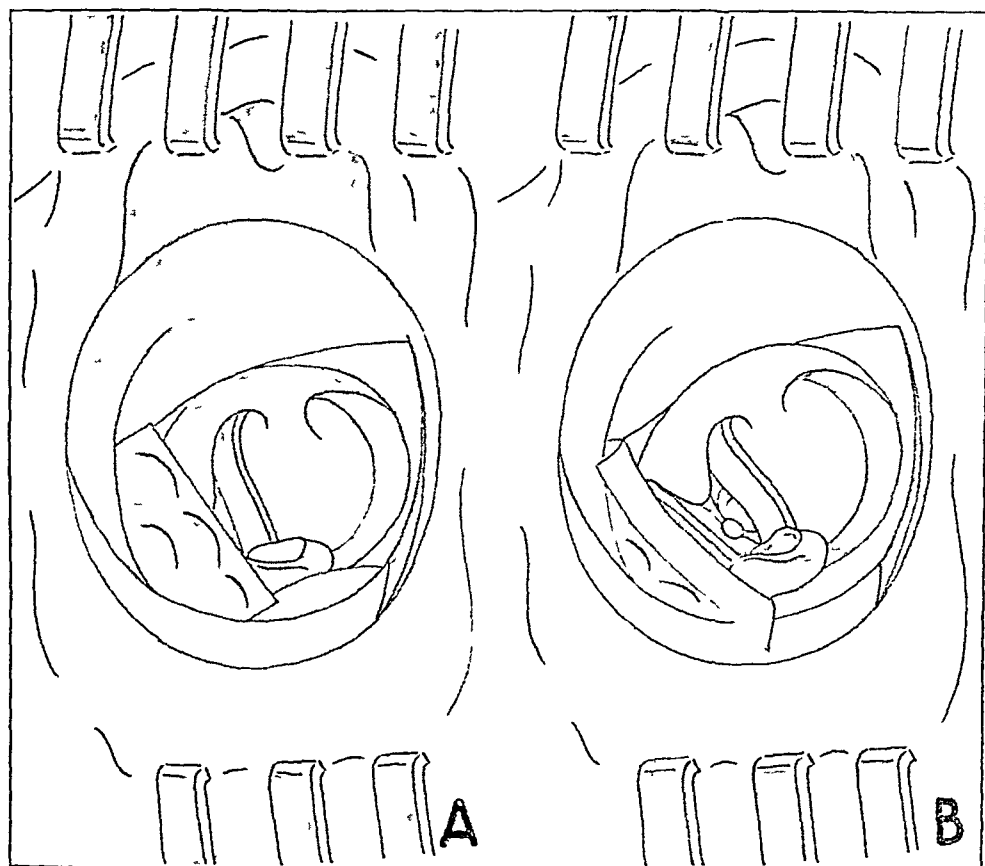


Fig 14—Stage 6. In *A* the incus has been removed, the attic is open up to the tegmen, the ampullar dome is clear and accessible, and the facial nerve with the blood vessel at its upper border. *B* shows the field prepared for a test for fixation of the stapes. The head of the malleus does not obstruct the view of the site of fenestration.

tion that after the incus has been removed during radical mastoidectomy the hearing that was present on the affected side is gone. In an address at the Annual Session of the American Medical Association in Chicago, on June 23, 1948, I put forward an explanation of the functions of this ossicle and urged that when the surgeon is doing atticoantrostomy for chronic otorrhea he in no circumstances disturb



the incus if the object of the operation is to restore hearing as well as to control the discharge. With the gentle technic of the transtympanic approach, the incus can be saved. In radical mastoidectomy, however, whether postaural or endaural, damage of the incus is difficult to avoid and the ossicle is frequently sacrificed, with corresponding inevitable loss of hearing. The loss is in the region of 40 decibels.

Such a loss will occur when the incus is removed, and on examination its lenticular process is found to be undamaged by disease.

The deafness is due to the tonic contraction of the stapedius muscle, which now, being unopposed, pulls the stapedial footplate out of the

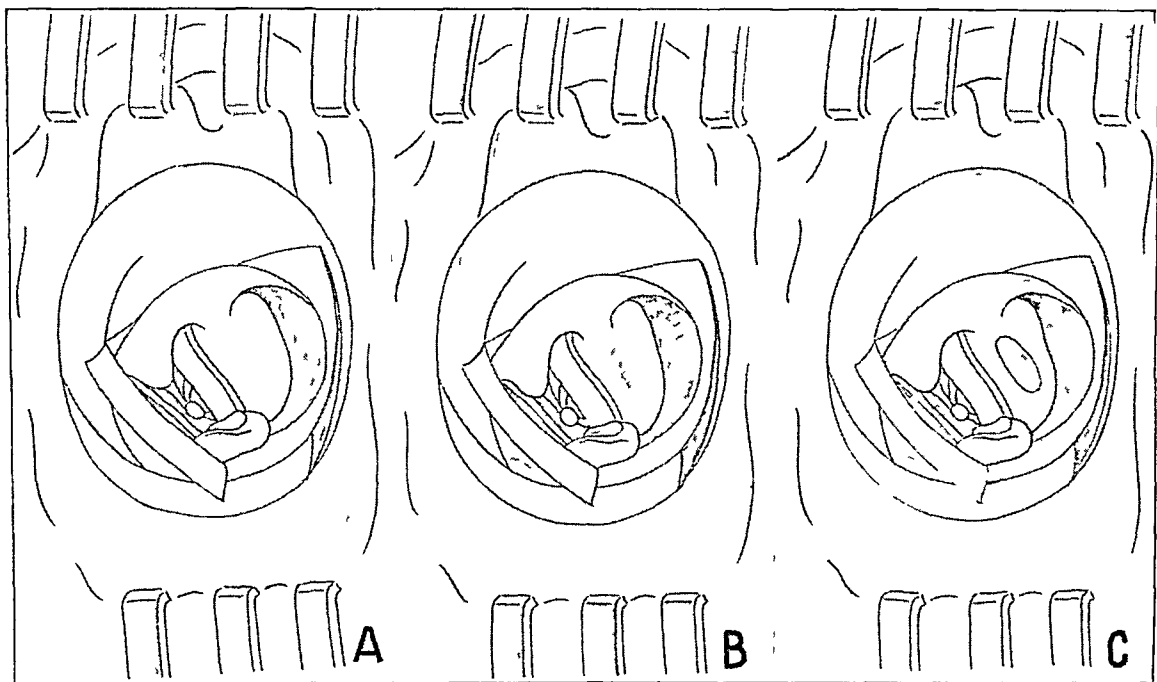


Fig 15—Stage 7 fenestration. In *A* the superior, anterior and lateral surfaces of the dome are being ground down. A gray line shows. In *B* the capsule is thinned further. The gray line darkens. In *C* the fenestration has been completed. The site is vertically over the stapes. The membranous canal is visible.

oval window. Excursions of the perilymph are dampened. As no opposing mechanism now exists to poise the footplate correctly, such dampening with consequent deafness will be permanent if stapedial muscular control is allowed to persist. This control must be banished. It is essential to divide the stapedial tendon between the eminentia pyramidalis and its insertion into the neck of the capitulum of the stapes. The stapes is now free, and hearing has been preserved by the labor of a few seconds.

It has been shown experimentally that stapedial excursions are two and even three times greater after the tendon is cut.

The ear is of course, deprived of the mechanism that protects the cochlea against acoustic injury (excessive noise)

If disease has involved the lenticular process together with the capitulum of the stapes and its tendon, tonic action affecting the footplate does not arise. This may account for the remarkably good hearing frequently encountered in the presence of chronic middle ear disease with obvious osteitis and cholesteatoma

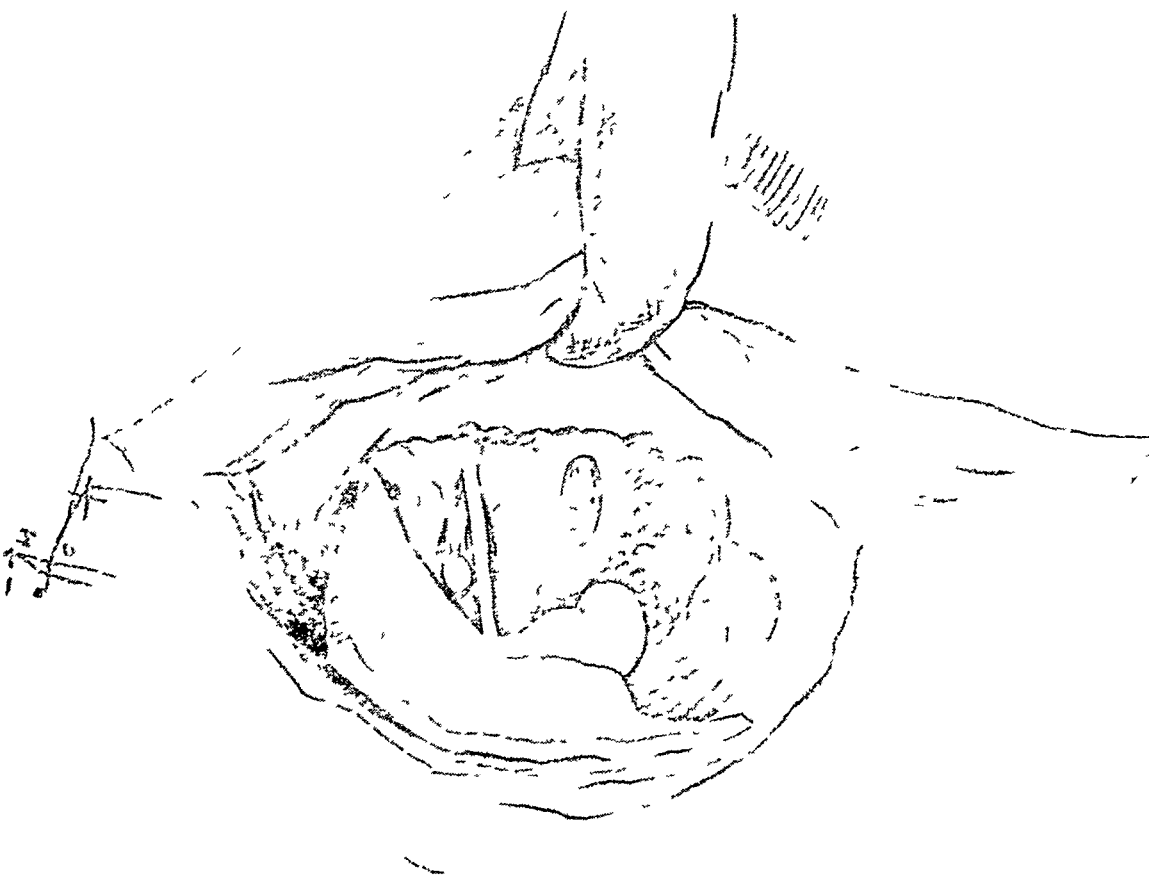


Fig 16—Realistic illustration of the exposed attic. Cortex still covers the antral region, it is removed as well in the current technic. Note the dome, the fenestra and the membranous canal, the facial nerve, the chorda tympani, the stapes, the stapedial tendon and eminentia pyramidalis, the round window, the tympano-meatal flap and the head of the malleus. The flap is about to cover the fenestra

With the end of stage 5, therefore—that is to say, with the incus still in position—the atticoantrostomy by the transtympanic approach has been completed. The attic and the antrum are carefully searched for any diseased material, which is removed either with Lempert curets or diamond burrs until a healthy base is seen. The meatal flap, in this instance hinged from its outer edge, is now replaced against the cleaned out attic and adapted to its new base by gentle packing. Viscose sponge material is used for this purpose. These small sponges are dipped in liquid petrolatum U. S. P. and covered with sulfadiazine powder,

and are used in the form of a rosary as shown later for the fenestration procedure

**STAGE 6—The Incus Is Removed** (fig 14)—The attachment of the incus is loose, and even the gentlest manipulation dislodges it from its bed. With a pair of fine forceps (ophthalmic) the long process is grasped and the whole ossicle gently lifted upward so as to avoid tearing the chorda tympani. The atticotympanic structures are now in view.

With removal of the incus the time has come to check the diagnosis of otosclerosis, or, in other words, to establish whether the stapes is fixed. After removing the cotton wool pellets which have packed off the tympanomeatal flap, it is possible to turn over the upper edge of the drum and inspect the entire stapes. The capitulum is now free, and I have found that in fixation it invariably is permanently tilted in a downward direction. I should be interested to know

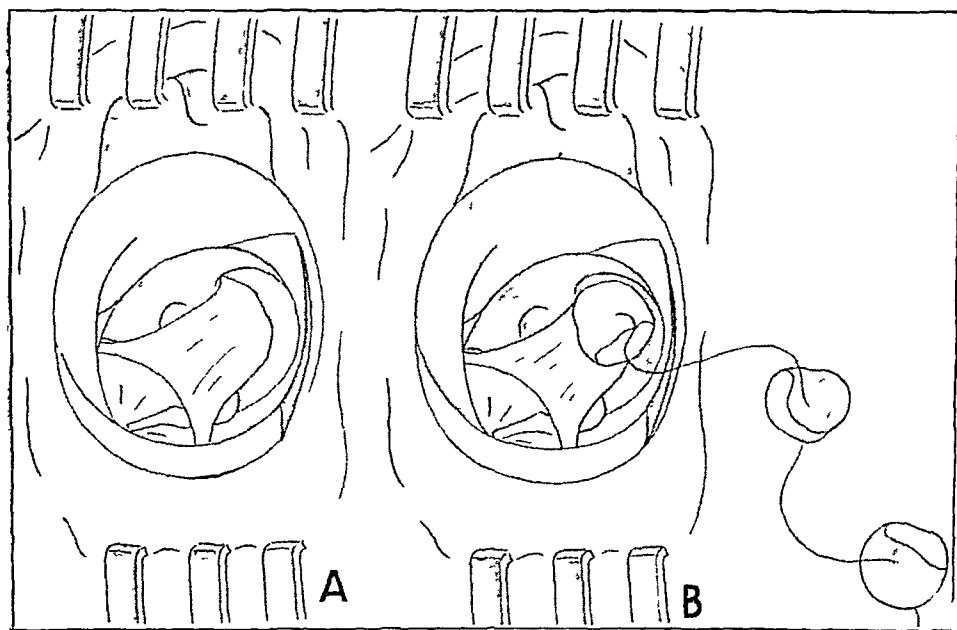


Fig 17—Stage 8. In *A* the tympanomeatal flap is replaced. In *B* a rosary-like sponge pack dusted with sulfadiazine is being applied.

whether this downward dipping is a constant characteristic in fixation, and colleagues' observations on this point will be welcomed. With a fine needle the capitulum is touched lightly, and it is almost invariably found that the fixation is absolute. The crura of the stapes are so delicate that if the slightest force is used they will fracture. It must be remembered that the diagnosis of otosclerosis is based entirely on presumptive evidence, and it is always a relief when this test is over. Should the stapes be freely mobile (and here one must make quite sure that the footplate is rocking with the capitulum and that the crura have not been fractured), it is purposeless to proceed to fenestration of the vestibular "dome." Lempert has described otosclerotic foci occurring in the round window region, and this would produce exactly the same symptoms as fixation of the stapes. In such an event, fenestration of the scala tympani is indicated. Such procedures are still in their experimental stage. After the test for stapedial fixation has been completed, the cotton wool pellets are again packed into the space below the

ledge of the tympanic plate to protect the tympanomeatal flap, and the stage is set for the actual fenestration procedure

STAGE 7—*Fenestration Is Performed* (figs 15 and 16)—Extra magnification with loupe or microscope is used in this stage I follow the teachings of Lempert

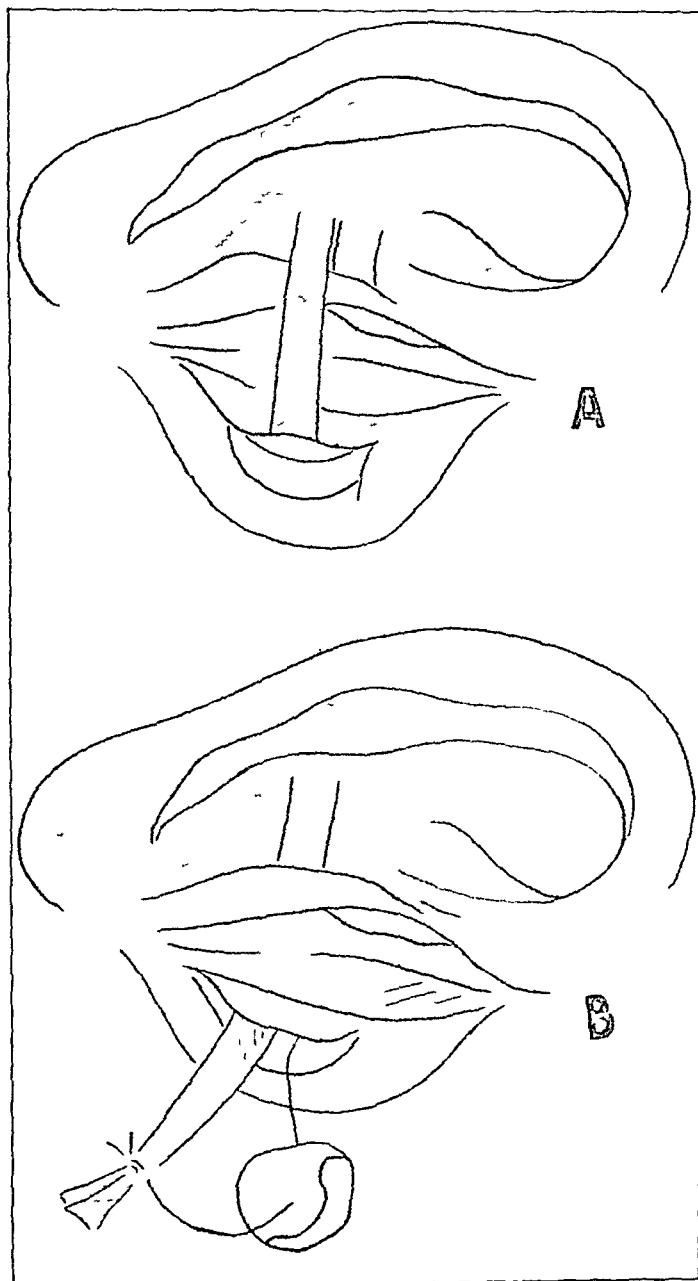


Fig 18—*A* shows the retractor released and the linen thread of the rosary pack attached to gauge in the meatus In *B* the linen thread is drawn into the meatus

closely and intend to use the lead burrs which he recommends when these are available The fluid state of thought on this subject is exemplified by the diversity of views expressed in different schools Any of the existing technics, including

that of uncapping, can be used in the transtympanic exposure with comfort and safety, and the ideal site vertically above the stapes is there for the asking. In fig 15A the ampullated "dome" is shown ground down superiorly, anteriorly and laterally, with the gray line of the eventual fenestration showing through. A further stage is shown in figure 15B, with the gray line showing through much darker. For this preliminary grinding down, the spherical diamond burr is most useful. At this point it may be changed for the flat end, inverted cone

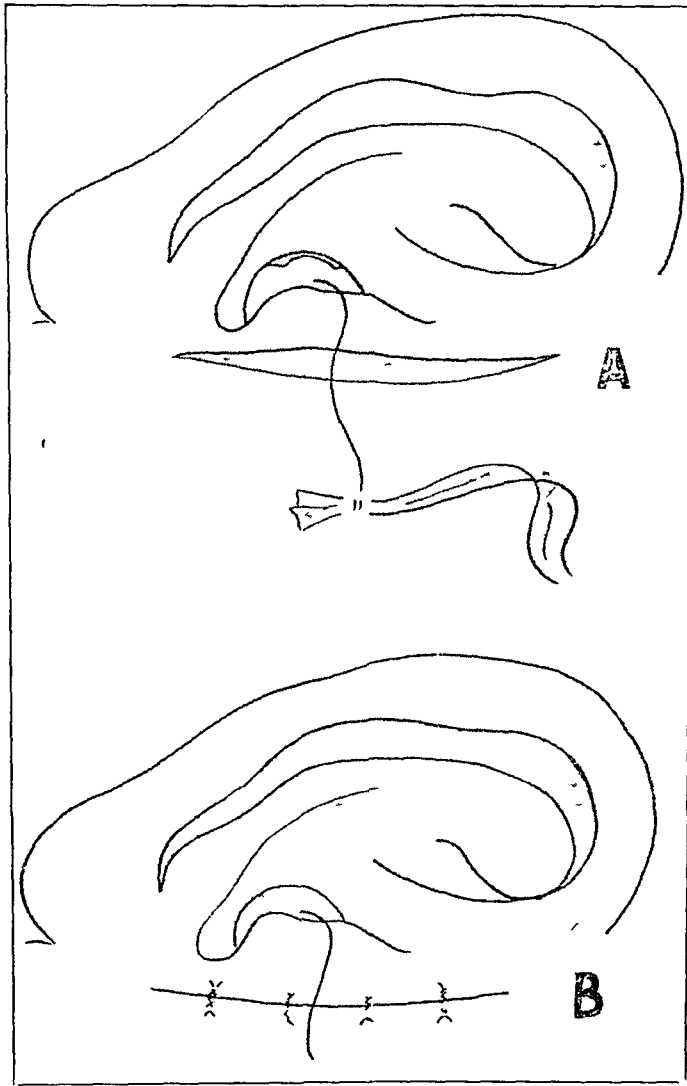


Fig 19—In A the meatus is lightly packed with a strip of the sponge material. In B the edges of the incision have been sutured.

diamond burr, which is played over this darkened gray line until fragments of endosteum, usually with some endosteal membrane attached, come away. During this maneuver, either continuous irrigation and suction or cleansing of the field every few seconds may be employed. Great care must be taken that the suction tube is placed nowhere near the fistula. All bone dust and fragments of endosteum and endosteal membrane are flooded away from the site of the fistula,

aspirated or mopped and the region carefully inspected after each irrigation to make certain that no vestige of debris remains behind. Tiny pellets of cotton wool soaked with penicillin solution are used to mop the surface of the fistula until eventually it has reached its maximal size and a few shreds of endosteum may be seen clinging to its sharp-edged rim. With a fine needle and with the field flooded with penicillin solution, these shreds are gently teased away without the needle entering the interior of the fistula. The field is mopped dry and the fistula inspected. When the shining endosteal membrane lining the cavity and the membranous canal can be clearly seen in the fistula as shown in figure 15C, one or other of the polishing burrs, lead or gold, may be used over the rim surrounding the site of fenestration<sup>6</sup>.

**STAGE 8—The Tympanomeatal Flap Is Replaced (fig 17)**—The protective cotton wool pellets and the rubber tissue are now removed from the osteal surface of the meatal flap overlying the tympanic membrane. The field is again flooded with penicillin solution, and the flap is gently teased away from its anchorage under the tympanic plate until it floats. In no circumstances must suction now be used, or one may find the flap in the suction bottle. The flap has a natural tendency to fall back to its original position. On gently mopping away the excess fluid, the flap can be made to sink down and cover the site of the fenestration like a ship gradually touching bottom in a dry dock. Before allowing the flap to settle, it is as well to inspect the fenestration again and make quite sure that no bleeding into the lumen has occurred. When this point has been satisfactorily settled, the flap is allowed to fall into position. Again with the use of minute cotton wool pellets, this time soaked in liquid petrolatum U S P, so that the flap may not adhere, the flap is adapted to its new position and the skin pushed closely into the fistula. Viscose sponges threaded on linen in the form of a rosary and soaked in liquid petrolatum U S P and dusted with sulfadiazine are convenient. These are packed gently over the flap until the attic is full. The interstices between the sponges allow ample drainage. The end of the linen thread is pulled from below through the meatus, care being taken not to dislodge any of the sponges in the attic. The meatus is lightly packed with a strip of the same sponge material, and the edges of the incision are allowed to fall together. Two or three sutures generally suffice or, preferably, Michel clips may be used. These are removed on the fourth day. There is no tension in this region, and the cosmetic result is perfect, the scar being barely visible even after one week. The meatal sponge is removed on the fourth day. Penicillin in oil is instilled three or four times daily. The patient usually is able to walk unassisted on the third day. The attic and flap sponges are removed piecemeal from the seventh to the tenth day. A forty-eight hour course of penicillin therapy is administered as a routine after operation.

#### COMMENT

A celebrated portrait artist once asked me to inspect a painting—my wife was the subject. When I reached his studio, I found the

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<sup>6</sup> Recently I had the opportunity of investigating the work of Dr. Samuel Rosen, of New York. Rosen developed the technic of implanting the chorda tympani in the fistula as a pedicle graft. The nerve is detached as it emerges from the facial canal and inserted in the fistula either as a single trunk or as one doubled on itself. The transtympanic approach affords an excellent exposure for this maneuver. The promising results of Rosen's technic will be capable of final evaluation in due course.

model still posing and was told to return the following day. To me the portrait seemed complete, and I was puzzled when, on the following day, I noticed no difference whatsoever. The artist explained this to me and confessed that he did add something but decided to remove the addition. I then asked him by what standards or what criteria he judged a work of art to be completed. I shall never forget his reply. He said, "A work of art is completed when it complies with three rules. Firstly, when the effect that the artist set out to produce has been achieved, secondly, if anything omitted would detract from this effect, and, thirdly, when anything added will not enhance the effect." It is my hope that with the help of my colleagues the transtympanic approach will stand up to this test.

The line drawings were made by Miss Ann West, B.A., from her own dissections. The other illustrations were presented to me by Dr Bello, of Buenos Aires, Argentina.

Prof Sutherland Strachan, of the department of pathology of the University of Witwatersrand Medical School, and his staff, with Prof W. E. Underwood, of the department of surgery, gave assistance and advice.

Fifth Floor, Lister Building

#### ABSTRACT OF DISCUSSION

DR DOUGLAS G. CARRUTHERS, Sydney, Australia. Since Dr Popper published the description of his method in the *Journal of Laryngology & Otology* in January 1946, I have performed that procedure many times on cadavers and a number of times on living subjects. I am in a position to consider the procedure which has been expounded to you today as a result of actual experience. Whichever of the incisions one may employ, I find that the field of access is not adequate without partial removal of the tympanic plate. Subperiosteal isolation of the tympanic plate is readily achieved, without risk of injury either to the facial nerve or to the temporomandibular joint and with but little hemorrhage. After one has gained access to the external auditory canal, the beautiful exhibition of the tympanic membrane and landmarks certainly is most impressive and satisfying. This is the only aural operation I know in which such a direct view of the drumhead is obtained. For that reason alone, it must find a useful place as a practicable approach to intratympanic and cochleovestibular surgical intervention.

The next procedure is to outline the flap of integument and to elevate it off the posterosuperior wall of the external auditory canal. This area presents itself "square on" to the operator. The flap can quite readily be stripped off the bone right down to the tympanic annulus, where, as a result of the clear view and direct access which have been provided, separation of the posterosuperior margin of the tympanic membrane, continuous with the base of the flap, can be performed so readily as to be surprising. The tympanic cavity is thus speedily and safely opened. Now the long process of the incus presents itself as an unmistakable landmark defining the exact site for the subsequent removal of overlying bone and clearly indicating the depth to which one has to cut away bone.

The only drawback of the whole operation, yet one which experience soon teaches one to master, is that when the stage is reached at which one has to use the engine-driven burrs, the field is found to be somewhat restricted. A contra-angled hand piece leaves a little more room. I am sure that a hand piece of more slender shaft can be designed so as to leave much more room for observation of the center of the field. Until the attic has been opened there is not much opportunity to use the burrs for side reaming. I would stress that there is no need to fear the procedure on account of this relatively small field which the

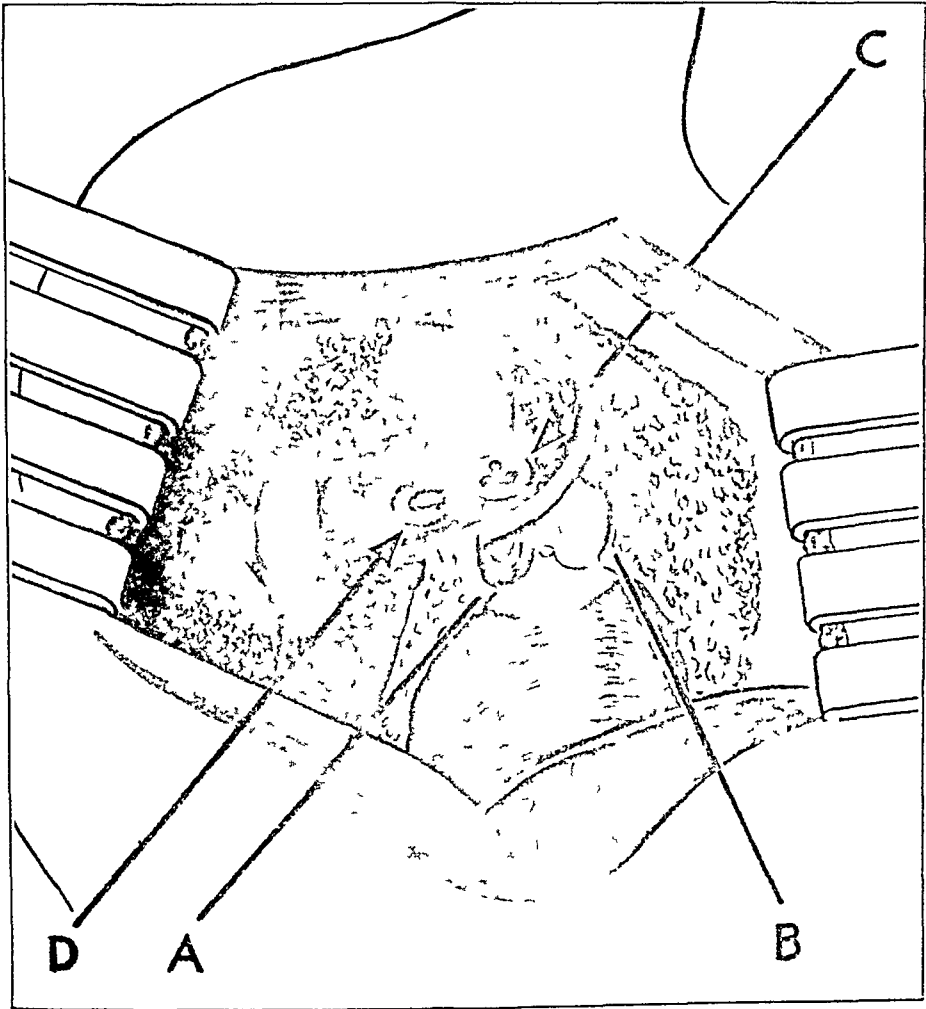


Fig 1—Fenestration by the transtympanic approach of Popper. *A*, posterior buttress of the annulus tympanicus, *B*, anterior buttress of the annulus tympanicus. Both *A* and *B* require to be taken down to insure a good "lie" of flap. *C* indicates a triradiate fistula made in fenestration of the dome, *D*, an oval fistula on the ampulla of the lateral canal. The ideal site is between *C* and *D*.

surgeon has to work in. A little practice on the cadaver soon gives the necessary confidence, and one learns how to adjust the lighting and the magnifying system so as to see what is being done. The body of the incus lies beneath the bone which is being removed, and if the operator should be a little heavy handed, it serves as a protection to deeper structures as the attic is entered. When in due course the incus is removed, the anterior-most portion of the external semicircular canal and adjacent wall of the vestibule are presented in relief right in the center of the field. There is no doubt whatsoever about where to make the fenestra so



that it will be as close as possible to the natural oval window I have always had some doubts about the accessibility of the true vestibule when using the endaural approach I have always felt that what was described as fenestration of the dome of the vestibule was fenestration of the ampullary end of the external semicircular canal I don't deny that the vestibule can be entered by the endaural route, but I feel that at the angle of approach from above and behind which is so provided, only a minute segment of the vestibular wall is accessible When employing the transtympanic route of Dr Popper one finds that the angle of approach is a full 90 degrees farther forward, and I do believe, as a result of careful studies of the highly magnified field of the cadaver, that it is practicable in many cases to expose the vestibular space anterior to the ampulla of the external canal with reasonable certainty Whether there is any real advantage in placing a fenestra so far forward is, of course, as yet unproved

The flap of integument used to cover the fenestra is extremely thin, and being cut deep to all cartilage, it is flexible and can be readily adapted to the site of fenestration I have been troubled much with excessive granulations in the depth of the canal, and later stenosis has been too frequent after this method has been used I believe that the tendency toward these unsatisfactory sequelae points to the necessity to make the bony atticomastoidectomy much more extensive and indicates also that the tympanomeatal flap should be much larger Both of these modifications of procedure are quite practicable via Popper's approach

I present to you in brief outline the histories and the audiograms of 4 of my patients who have been operated on by Dr Popper's method They serve to support the claim that an improvement in hearing comparable with that of any other method can be achieved by the transtympanic approach I am attracted to the method because of its simplicity and because the access obtained is so much more direct than that by any other approach I would stipulate, however, that much as one may have operated by other methods, an attempt at a new approach is not always easy Just as otologists have had to prepare themselves for the endaural method by assiduous and often repeated practice on cadavers, so they must do this again before it is reasonable that they will correctly assess the new method The surgeon who would just try the transtympanic approach once or twice, and be turned back by its little difficulties rather than master them, will, I am sure, deprive himself of much of the pleasure which comes of being able to orientate oneself to a new surgical environment I still operate by both Lempert's and Popper's approach and I have many technical points which are my own I am not prepared to say yet that any one method is entirely better than the other

The major significance of Dr Popper's work as I see it is that he has devised a simple and practicable anterior transmeatal approach to the posterior portion of the tympanic aditus and vestibuloampullary area As such it will be, I am sure, of lasting use in the practice of otologic surgery

DR ARTHUR L JUERS, Chicago I commend Dr Popper for his diligent efforts to improve the surgical approach to the middle ear region and the position of the fenestra However, as far as fenestration is concerned, I cannot, at present, conceive of sufficient advantage of the transmeatal approach over the Lempert endaural technic to warrant using the transmeatal route Several months ago Dr Shambaugh modified the regular endaural technic by cutting the flap and freeing it almost down to the tympanic ring before opening the mastoid cortex I have since adopted this change and I find that it facilitates the early part of the operation This modified endaural approach, in addition to utilizing the meatus as part of the avenue of approach to the labyrinth, affords the surgeon an oppor-

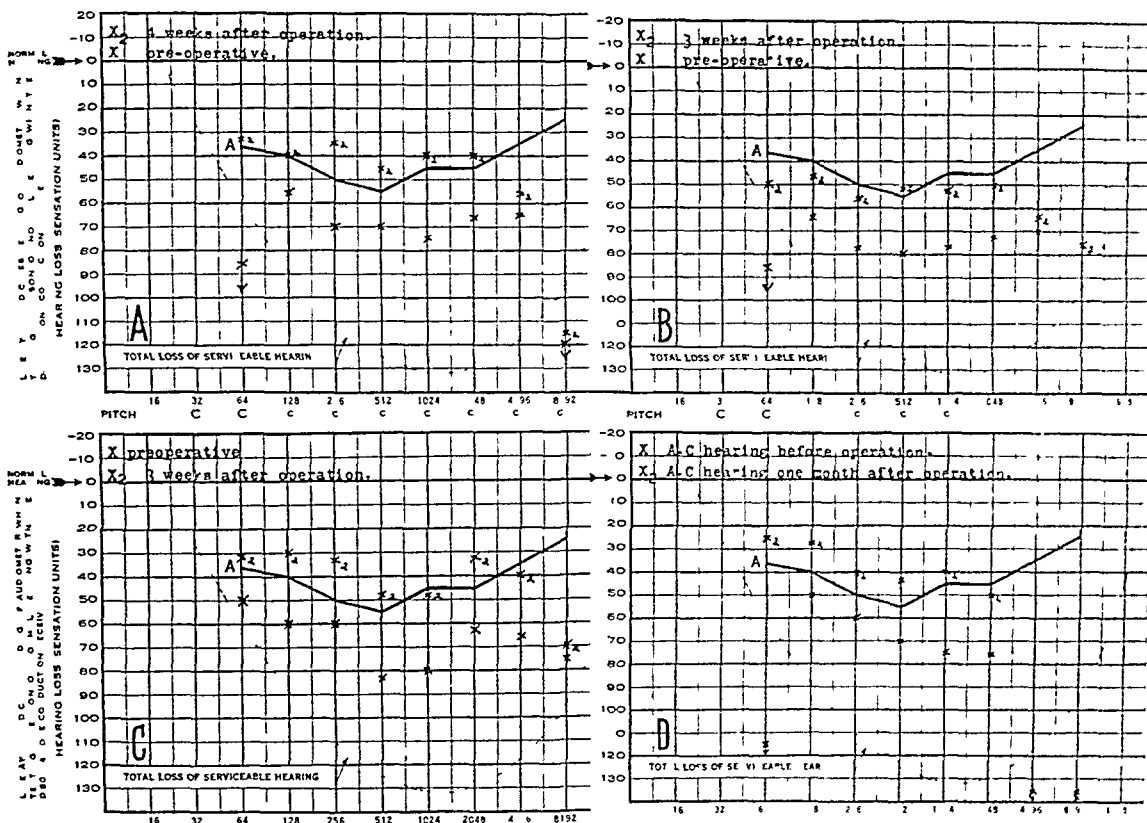


Fig 2—Audiograms of patients on whom fenestration was performed by the method of Popper. A, audiogram of N J, aged 13. Deafness had been progressively increasing since the age of 9 years. The father was deaf, his loss of hearing having started when he was 10. Several aunts were deaf. No deafness was found on the mother's side. The patient had no other ear troubles. The nose and the throat were healthy. The ears appeared normal. The eustachian tubes were patent. The Rinne test showed hearing by bone conduction much stronger than that by air conduction. An audiogram revealed nearly normal bone conduction in both ears except for a loss of perception of 8192 cycles. Fenestration of the left labyrinth was performed by Popper's technic on April 5, 1948. Healing was uneventful. There was marked improvement in the patient's hearing of normal conversation. The postoperative audiogram confirms the improvement in hearing. The average gain throughout the speech range was 30 decibels.

B, audiogram of Mrs W R, aged 31. She had noted deafness, especially of the left ear, for about five years. The father was deaf. A grandmother and one cousin were deaf. The patient has no other ear troubles. The ears appeared healthy. The eustachian tubes were patent. The Rinne test showed hearing by bone conduction stronger than that by air conduction in both ears. In the Weber test the sound was central. A bone conduction audiogram with masking, indicated fair but uniformly reduced cochlear activity in both ears. An air conduction audiogram indicated that the hearing of the left ear was 10 to 15 decibels poorer than that of the right. On Oct 27, 1947 fenestration was performed on the left labyrinth by Popper's method. The membranous labyrinth was intact and there was an intact flap. Rather exuberant granulations were observed in deep portions of the external auditory canal during convalescence but were completely healed on Dec 12, 1947. The audiogram reveals 25 to 30 decibels gained in the speech hearing range. The gain has been maintained.

C, audiogram of Mr G W, aged 35. His deafness was of gradual onset, especially during the past five years, and was worse in the left ear. There had been no previous ear troubles. No relatives were deaf. The drumheads revealed slight opacity only. The eustachian tubes were patent. The Rinne test showed

(Legend continued on next page)

tunity to remove as much additional bone as is necessary to provide adequate exposure of the lateral semicircular canal. An attempt to carry out fenestration by the transmeatal approach described by Dr Popper without removing the entire lateral wall of the mastoid antrum would make an already difficult surgical procedure more difficult. The mastoid antrum must be opened widely if an adequate removal of periosteal bone from the lateral semicircular canal is to be accomplished (enchondralization). Furthermore, if all the bone lateral to the antrum is not removed, then there exists after operation a recess or pocket which would undoubtedly, in some instances, be invaded by squamous epithelium from the distal end of the flap, and a cholesteatomatous mass might be formed eventually. If by the endaural technic the operative cavity is kept as small as is compatible with providing adequate exposure of the lateral semicircular canal, and if strict asepsis is observed in the early postoperative treatment as well as during the surgical procedures the after-care of the cavity will be relatively simple.

The size of the flap described by Dr Popper would be inadequate to seal off completely the middle ear in the anterior area of the attic. I believe that this failure to seal off the middle ear would in some instances result in a permanent perforation of the attic with subsequent poor improvement of hearing.

Dr Popper has stated that he prefers to place the fenestra anterior to the position of the fenestra nov-ovalis. After doing some detailed dissections of the lateral semicircular canal and the lateral wall of the vestibule, I find that I cannot agree that it is desirable to attempt to place a fenestra anterior to the present nov-ovalis position. There are, in my opinion, three reasons why this more anterior position is not desirable.

1 At the point where the membranous canal joins the ampulla, the perilymphatic space begins to turn inferiorly and medially. In this region the course of the facial nerve is in an anterior and superior direction, and any attempt to place the fenestra on the anterior surface of the ampulla would place it unnecessarily close to the facial nerve.

2 If an attempt is made to place the fenestra on the anterior aspect of the ampulla, the branches of the vestibular nerve supplying the ampullae of the lateral and superior canals might be severed. This is obviously undesirable.

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hearing much stronger by bone conduction than by air conduction. In the Weber test the sound was central. An audiogram revealed good hearing by bone conduction in both ears. The tonsils were suspected and removed, and the antrums were washed out and treated with penicillin as a precautionary measure prior to fenestration. On Feb 9, 1948 fenestration of the left labyrinth was performed by Popper's approach. The membranous labyrinth was intact, and the flap was intact. On February 27 the fistula response was active, the flap and the fenestration area were healed. There were granulations tending to project into the deep portion of the meatus. Hearing was greatly improved. The audiogram reveals a gain of over 30 decibels in the speech range.

D, audiogram of Mrs W. H., aged 42. Deafness, worse in the left ear, started after pregnancy when the patient was 30. There were no other ear troubles. No relatives were deaf. The nose and the throat were healthy. The ears appeared normal. The eustachian tubes were patent. The Rinne test showed hearing by bone conduction much stronger than that by air conduction. An audiogram revealed hearing by bone conduction to be almost normal except for a sharp drop at 4096 and 8192 cycles. Fenestration was performed on the left labyrinth on Jan 22, 1948. Healing was uneventful. Postoperative audiograms taken on February 18 indicated a gain of about 25 decibels throughout the speech range. As anticipated, there was no lift at the high end of the auditory spectrum. In May, four months after operation, the hearing gain was still well maintained.

3 If the entire fenestra is placed directly over the ampulla, it is quite possible that the patient will be subject to more unsteadiness on quick movement in years to come than he would be if the fenestra were placed somewhat more posteriorly, with less exposure of the ampulla

From a physiologic standpoint I believe that the best position of the fenestra may be on the most lateral aspect of the canal, because this provides maximum phase difference for a sound wave at the fenestra and the round window

My colleagues and I will await with anticipation more extensive and more conclusive long range clinical reports as to results obtained by Dr Popper's fenestration technic

DR SCOTT STEVENSON, London, England I had no intention of taking part in this discussion this afternoon, but I could not resist the opportunity of congratulating my old friend, Dr Popper, on the ingenuity of his operation In our hospital, where we have done a certain number of operations of this type, we have been inclined to teach our students that the difficulty is in the flap rather than in the fenestra, and I do think that Dr Popper's operation seems to make the handling of the flap easier It has been pleasant to be here, because some twenty years ago he and I worked together as juniors in University College Hospital in London, and it was a great loss to England when Dr Popper made up his mind to go back to South Africa

I take the opportunity of conveying greetings to you from the British Medical Association and also from the Royal Society of Medicine We will have an international congress in London in July 1949, under the presidency of Mr Victor Negus, our leading laryngologist I have been asked to give the most cordial invitation to all the members of the Section on Laryngology, Otology and Rhinology of the American Medical Association to come to the international congress next year You will find that conditions in England are not as bad as they were—not as opulent as they are over here, of course If you live in hotels you will not find anything much wrong at all, our Ministry of Food turns a somewhat blind eye toward hotels and restaurants, and we encourage visitors, of course We can certainly promise any otolaryngologist who comes over next year a good time

DR OTTO POPPER, Johannesburg, South Africa Dr Juers stated that he sees no advantage in doing my operation, over the accepted method The advantage is that you omit the preliminary radical mastoidectomy Naturally, it is a question of how great you consider this advantage There are some who consider it very great, more particularly surgeons in Scandinavia, Holland, France, Argentina and elsewhere who have done many hundreds of operations according to my method I have just had a letter from Professor Lund, of Copenhagen, who is publishing his first series

May I say, let us leave the comparison until a time five or six years hence, when it can be adequately determined whether my method should be thrown onto the scrap heap or whether it will endure? Nothing I can say will help It is only the intrinsic merit of the operation that will allow it to survive

I am particularly honored that such an international celebrity as Dr Carruthers should fly 10,000 miles to support me, and I am grateful for the courageous way in which he has expressed himself Douglas Carruthers' classic on rubella and deaf-mutism is medical history and has placed him in the front rank of famous otologists To have won the approval of such a careful and painstaking investigator is a great encouragement

I am grateful to my old friend Scott Stevenson for his kindly thought, we starved together in those heppay London days and I rejoice and would like it to go on record that he approves—even if it has taken him two decades to do so

I thank you, gentlemen, very much

# ACOUSTIC, VESTIBULAR AND OTHER PROBLEMS CONCERNING OTOSCLEROSIS AND ITS SURGICAL TREATMENT ACCORDING TO POPPER'S METHOD

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## I POPPER'S OPERATION FOR OTOSCLEROSIS

ROBERT LUND, M D

**I**N JANUARY 1946 Popper<sup>1</sup> brought out his "new, safer and less traumatic approach to the labyrinth—the transtympanic route" His technic offered such a striking simplification of the operation for otosclerosis as compared with previous methods that I decided to try it

In the course of years, as is well known, the site of the labyrinthine fenestration has gradually shifted more and more forward from the lateral limb of the ampulla of the lateral semicircular canal to the ampulla itself and finally to the very roof of the vestibule, above the facial canal In the employment of the Lempert operation, however, the transmastoidal route has been preserved In this way the lateral semicircular canal is placed anteriorly in the operating field, it is true, but this technic is less suitable when it is desirable to place the fistula in the cupola of the vestibule corresponding to the lateral ampulla and the area in front of this, because this portion of the labyrinth is not directly accessible

These features are illustrated well in figure 1, a drawing taken from Popper's article<sup>1</sup>

In figure 1 the line *1—1* is the axis of the labyrinth as related to the cranium The arrow *L* shows the direction of the approach in Lempert's transmastoidal method, i e, an oblique approach, which naturally makes the chiseling technic more difficult The arrow *P* gives the direction of the approach—thus, also the drilling direction of the burr—in Popper's method, i e, the approach is "square on" the operating field, perpendicularly on the vestibule, where the fenestra is to be drilled, and this naturally means a much easier approach *T* indicates that part of the labyrinth which is covered by the anterior tympanic

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1 Popper, O F J Laryng & Otol 61 24 (Jan) 1946

plate, 1 e, the cupola of the vestibule *M* indicates that part of the labyrinth which is covered by the mastoid process and its pneumatic cells, 1 e, the area of the semicircular canal In other words, if one is to operate on the vestibule, or merely on the lateral ampulla, a really "square-on" working field may be obtained only by going through the anterior wall of the meatus

Now I shall describe briefly the Popper technic with those modifications which I have found advantageous

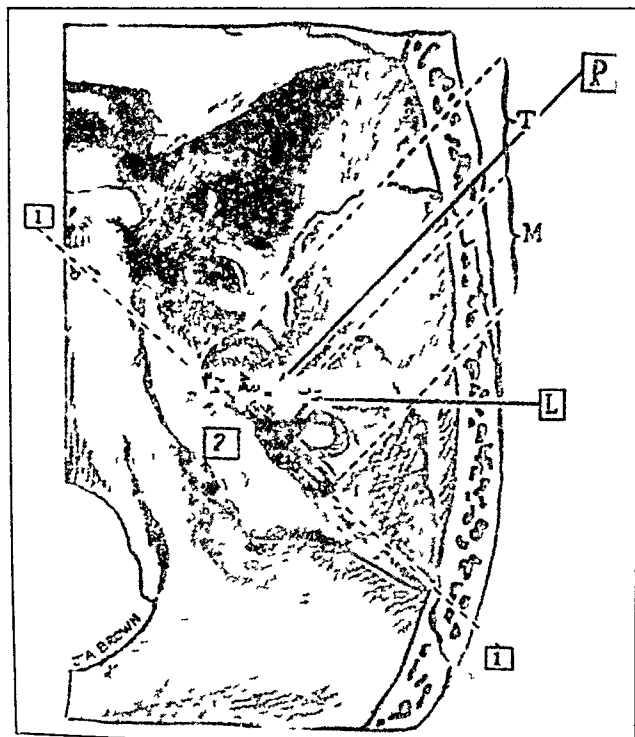


Fig 1 (after Popper<sup>1</sup>)—1—1, the axis of the labyrinth, shows that this structure is inclined at an angle of 45 degrees to the sagittal plane *M* includes the part of the labyrinth covered by the mastoid process *T* includes the part of the labyrinth covered by the tympanic plate *P*, an arrow, shows the direction of the transtympanic approach and the "square-on" presentation of vestibule *L*, an arrow, shows the direction and the oblique presentation of the operative field in the transmastoidal approach *2* is opposite the vestibular region of the labyrinth

#### TECHNIC

The head of the patient is not placed in side position but is turned halfway upward

Figure 2 *A* shows the incision made by Popper through the skin I make an incision that is more curved, with its convexity forward (fig 2 *B*) This gives better cleavage As will be noticed, the incision is extended a little down into the anterior part of the auricular lobule

An approach is made at once to the cartilaginous part of the anterior wall of the external meatus, which is uncovered by means of an elevator (naturally, the perichondrium is preserved) down to the bony part of the anterior wall of the

meatus (the tympanic plate) These maneuvers imply no risk of injuring branches of the facial nerve or the parotid gland as long as the surgeon keeps close to the cartilage and bone

Now a jaw lever is applied so that the mouth is kept wide open, as this gives more room for operating Then, with a rectangular knife, the incision is made into the anterior wall of the meatus, separating the cartilaginous part of the wall from the bony part The tragus plus the cartilaginous anterior wall of the meatus are pulled backward with a retractor The periosteum is detached from the anterior aspect of the anterior wall of the bony meatus Then the entire anterior wall of the bony meatus is removed by means of a rongeur, almost to the edge of the tympanic membrane

Popper here sacrifices the cutaneous lining of the tympanic plate In some of my cases a postoperative constriction of the meatus resulted from this procedure, and in 4 cases it even became necessary to reoperate almost in the form of a conservative radical operation Therefore, I have sought to preserve the skin that

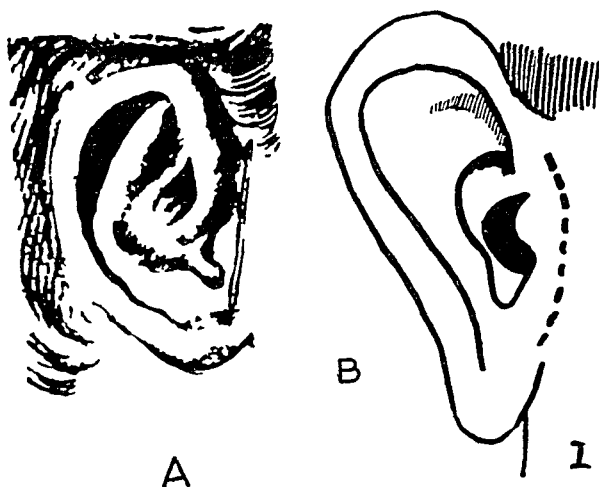


Fig 2—A, Popper's incision, made through the skin anteriorly to the tragus (after Popper<sup>1</sup>) B, Lund's incision

lines the tympanic plate by elevating it before removing the tympanic plate with the rongeur This skin is pressed forward against the periosteum from the bone removed, leaving a free view into the depth

Now the inner half of the meatus is accessible to the full extent, leaving a "square-on" field of the posterior wall of the meatus and the tympanic membrane

After this, Popper forms a tympanomeatal flap to be placed over the vestibular fenestra as follows After the meatal integuments have been infiltrated with a procaine hydrochloride solution, an incision is made about 1 cm from the tympanic membrane in all the remaining portion of the bony meatus clear down to the bone This flap is detached together with the tympanic membrane for about two thirds of the circumference of the latter To begin with, I also employed this method, but later I modified it, as it was found to be connected with a tendency toward post-operative constriction of the inner half of the meatus So I adopted the following procedure, with which meatal constriction is sure to be avoided

In the first place I do not infiltrate the skin in the depth of the meatus, as this procedure has proved to involve the risk that the tissue which marks the transition

between the meatal flap and the tympanic membrane at the annulus tympanicus may become fragile, with the result that a break of continuity may take place here, and such an accident would be rather annoying. Besides, this anesthesia is superfluous.

The flap is formed as shown in figure 4 *B*, where the area marked  $\alpha$  forms the most internal part of the anterior wall of the meatus, and the area marked  $\beta$  is the most internal part of the upper posterior meatal wall.  $\alpha$  shows the line of incision made at the formation of the anterior skin flap mentioned earlier.  $\beta$  is the skin flap that is to cover the vestibular fenestra, upward and posteriorly it is made 1 cm broad, but downward in the posterior meatal wall it is narrowed considerably, and in the upper meatal wall it is narrowed somewhat anteriorly. Moreover, I do not detach the tympanic membrane to the large extent described by Popper. For

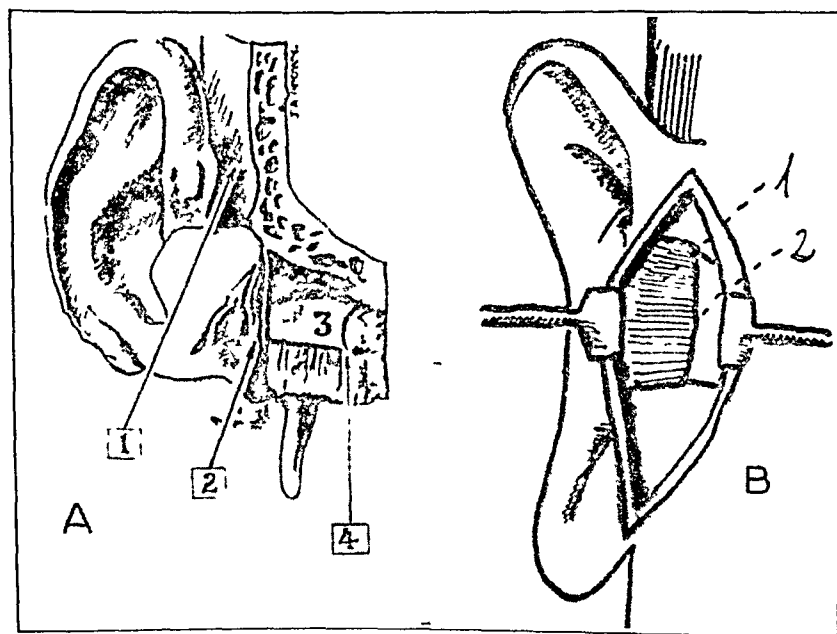


Fig 3—In *A* (after Popper<sup>1</sup>) arrow 1 indicates the incision illustrated in figure 2. Arrow 2 indicates the second incision, made through the line along which the cartilage is attached to the tympanic plate. 3 locates the tympanic plate—removed. In *B* the cartilaginous part of the anterior wall of the external meatus is indicated by 1, the pars tympanica, or tympanic plate, by 2.

I have found it sufficient to loosen the area corresponding to incisura Rivini, i. e., the pars flaccida plus about 2 mm of the pars tensa membranae tympani, just below the posterior tympanic spine—as indicated by the broken line above in the periphery of the tympanic membrane in figure 4 *B*.

After adopting these incisions my associates and I encountered no more instances of postoperative constriction of the meatus.

Now the meatal flap plus the pars flaccida is turned forward over the tympanic membrane as shown in figure 5, thus there is presented a "square-on" approach to the lateral bony wall of the attic.

Popper removes the lateral wall of the attic by cutting it down to a very thin barrier of bone by means of a burr and then removing this thin sliver. Without taking any risk, this step may be carried out more easily as follows. With a 2 mm



burr a hole is drilled in the middle of the attic wall (fig 5 *A*,  $\alpha$ ). Then the resulting "bridge" (fig 5 *A*,  $\beta$ ) is removed cautiously with a small straight chisel. The hole in the bony wall is widened by means of the chisel and a punch.

Here it may be mentioned that under these operations it has been my experience that the lateral bony wall is subject to rather wide variations, the extremes of which are given schematically in figure 6.

In figure 6 *A* the lateral bony wall ( $\alpha$ ) is seen to be almost vertical in relation to the upper wall of the meatus. In figure 6 *B* the wall of the attic is seen practically to continue in the upper wall of the meatus. In the first case the attic wall is thin and easily accessible, in the latter case it is thick and more difficult to work on with burr and chisel.

After the attic wall has been removed, the incus shows itself in the opening. By means of a fine periosteum knife it is detached from its articular connection with the

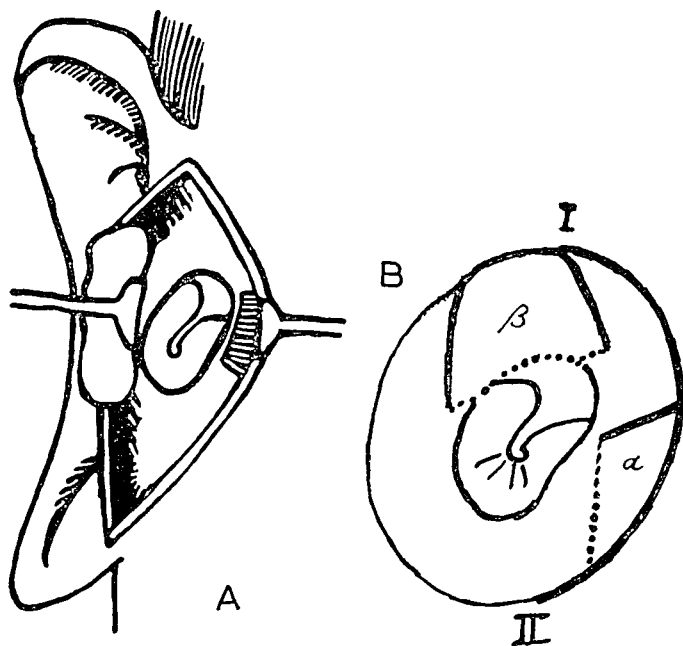


Fig 4—*A* shows the "square-on" presentation of the posterior wall of the external meatus and the drum. *B* shows the incision made through the skin that lines the anterior wall of the bony meatus ( $\alpha$ ) and that made through the skin that lines the upper posterior part of the bony meatus ( $\beta$ ). The broken lines give the extent of the detachment of the margin of the tympanic membrane. The curved line *I*—*II* marks the incision of the anterior wall of the external meatus between the cartilaginous and the bony part.

head of the malleus and then removed. It is unnecessary to sever beforehand the articular connection between the crus longum incudis and the capitulum stapedis.

After the incus has been removed, the vestibular cupola shows above the distinct facial canal, and the fenestration is performed with the burr perpendicular against the cupola—without the least risk of injuring the facial canal.

Popper drills the fenestra in the vestibulum with a 2 mm burr, which is applied just above the facial canal. The hole thus made is circular, with a diameter of 2 mm, the burr being held "rock-steady" on the drilling site. As Shambaugh has demonstrated experimentally that new formation of bone takes place from the outer periosteal bone of the labyrinthine capsule, I first remove the periosteal bone layer of the cupola. Then, by means of a 2 mm burr, an elongated hole is made in the

most prominent part of the cupola. This hole is widened by means of a fine spatula or a periosteum knife, care being taken not to injure the labyrinthine endosteum under the edges of the fistula, as—according to Shambaugh—such an injury would have a tendency to bring about osteogenesis. The resulting fenestra is about 2.5 to 3 mm long and about 1.5 mm wide. Posteriorly in this fenestra, the ampulla of the lateral semicircular canal is seen, anteriorly a cistern of perilymph separates the sacculus from the endosteum, hereby the membranous labyrinth is protected during the widening of the fenestra.

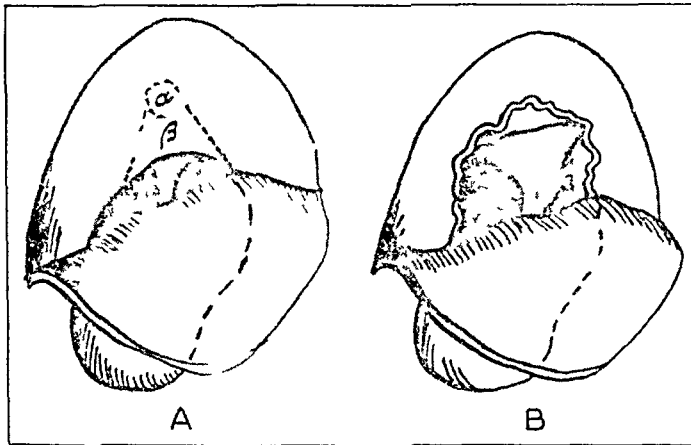


Fig 5—A shows the pars flaccida of the tympanic membrane plus the meatal flap reflected forward over the tympanic membrane. The crus longum incudis is seen in the depth. A hole is drilled in the lateral attic wall over the vestibular space (α). The "bridge" (β) is chiseled off.

B shows the hole of the lateral attic wall widened, the incus presenting a relief of the facial canal is seen in the depth.

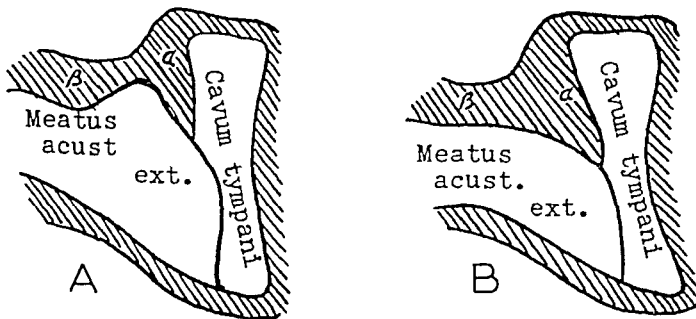


Fig 6—A, specimen in which the lateral bony wall of the attic (α) is almost vertical in relation to the upper wall of the meatus (β). B, specimen in which the attic wall is practically continued in the upper wall of the meatus.

Of course, while this drilling is performed the field is being continuously irrigated with Ringer's solution for the removal of the bone dust. Under no conditions is suction to be applied directly to the fenestra opening, as in that way the membranous labyrinth might be injured—an accident which occurred a few times in the earlier operations. In those cases the vestibular function was abolished in part, whereas the acoustic part of the labyrinth was not affected (thus there was no infection of the membranous labyrinth). After the drilling, the tympanomeatal flap is placed over the fenestra. The flap is kept in place by tamping it loosely with

ribbon gauze impregnated with Ringer's solution to which sulfathiazole and penicillin have been added.<sup>2</sup>

The cutaneous incision is sutured with silk or nylon. After a few weeks the scar anterior to the tragus is invisible.

The operation is performed with the patient under general anesthesia induced by intravenous injection of scophedal<sup>®</sup> 3 (about 0.6 to 1.5 cc). Further, anesthesia

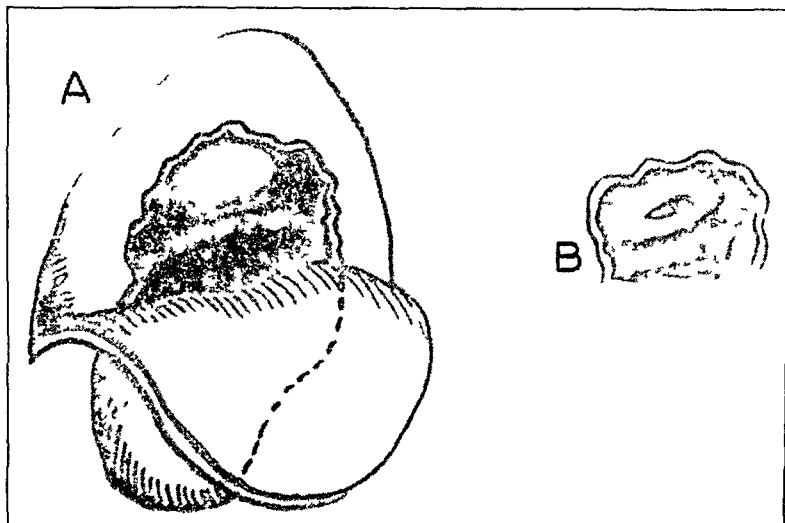


Fig 7—*A* shows the vestibular cupola presenting plainly above the distinct facial canal. In *B* the outer periosteal bone of the cupola has been cut off flat. Posteriorly in the oval fistula, the ampulla of the lateral semicircular canal is seen.

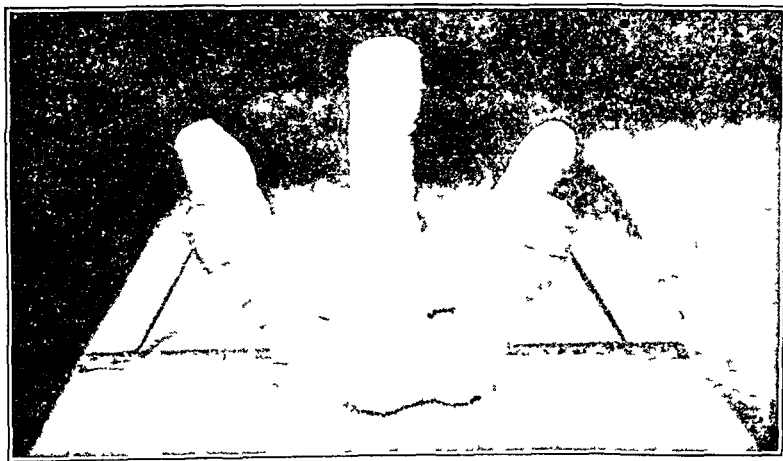


Fig 8—Head rest recommended by Shambaugh, use of which prevents any blood or exudate from entering the cochlea after operation.

2 The sulfathiazole-penicillin solution is made as follows: 0.5 Gm of sulfathiazole sodium and 10,000 Oxford units of penicillin dissolved in 10 cc of Ringer's solution.

3 Scophedal is the trade name under which E. Merck, of Darmstadt, Germany, markets a solution containing in each cubic centimeter scopolamine hydrobromide 0.5 mg, dihydrocodeinone hydrochloride (eukodal<sup>®</sup>) 10 mg and racephedrine hydrochloride 25 mg.

of the entire vicinity of the external ear is obtained with subcutaneous infiltration of a solution of procaine hydrochloride containing epinephrine hydrochloride

For two and one-half days prior to the operation the patient is prepared with sulfanilamide, 1 Gm six times daily. After the operation this medication is continued, and in addition 300,000 units of penicillin is given daily. On the sixth day after the operation the medication is discontinued. The first change of bandage takes place six days after the operation, and after this the bandage is changed daily, gauze impregnated with sulfathiazole-penicillin-Ringer's solution being put in continuously. In two to five weeks the meatus will be lined with skin throughout.

After the operation the patient is placed in the bed with his face turned straight upward, and the head is fixed in this position by means of a padded iron frame as recommended by Shambaugh. The purpose of this is to avoid the possibility that blood and exudate may come from the site of the fistula into the cochlea, which with this position of the head lies above the vestibulum. As far as that goes, this arrangement is also agreeable to the patient, who is inclined to become dizzy on movements of the head.

#### ADVANTAGES OF POPPER'S METHOD

The advantages of the Popper operation, compared with the trans-mastoidal operation, are as follows:

- 1 The entire operation is performed under excellent survey, with "square-on" presentation of the posterior wall of the bony meatus. Thus the tympanomeatal plastic flap can be loosened easily and rapidly, without being preceded by the time-consuming thinning and removal of the bony wall of the posterior meatus.

- 2 The tympanic membrane has to be loosened only to a slight extent (even less than the extent given by Popper).

- 3 There is a "square-on" presentation of the site of fenestration in the vestibular cupola. The facial canal is sharply defined in the middle of the field, so that any injuring of this structure can be avoided with certainty.

- 4 The entire mastoid process is left intact—which also saves time.

- 5 The tympanic membrane does not have to be "stretched" as recommended by Lempert, because here the fistula is situated so far anteriorly that it is covered easily simply by laying the tympanomeatal flap down, moreover, the flap even extends out on the medial wall of the antrum.

- 6 It is unnecessary here to remove the head of the malleus—this is done in Lempert's method—because the plastic flap is sufficiently large to make the aforementioned "stretching" superfluous.

- 7 The operative trauma is considerably smaller than with the procedure given by Lempert.

On account of these considerable technical conveniences of the Popper method, the operation itself can be carried out in an hour and a half—unless some particular complication turns up, e. g., hemorrhage. Now and then one may accomplish it even more rapidly.

As mentioned, during my work with the Popper method I have found occasion to modify the Popper technic on five points:

## ADVANTAGEOUS MODIFICATIONS OF POPPER'S TECHNIC

1 The skin on the inner surface of the anterior part of the osseous wall of the meatus—i e, on the pars tympanica—is preserved

2 The meatal flap is cut as an inverted "U," i e, with its width corresponding to the attic wall

Only when these two modifications are adopted may postoperative constriction of the meatus be avoided with certainty

3 A technical advantage, even though less important, is the circumstance that the attic wall is perforated with the burr at once—instead of the slow drilling with the burr

4 It is of not inconsiderable significance that the tympanic membrane has to be loosened only corresponding to the membrana flaccida and the spina tympanica • posterior

5 The change in the technic of drilling the vestibular cupola is of considerable importance, i e, the periosteal layer of the bone is cut away corresponding to the site of the fenestration and its immediate surrounding

After we had been applying this technic for nearly a year, we received, in Copenhagen, the number of the *Journal of Laryngology and Otology* issued in August 1946 This issue brought a new paper by Popper<sup>4</sup> concerning his operation, in which I noticed that during his further work he had found occasion himself to modify the technic on some points Thus, Popper now employs the same technic that I do for removal of the attic wall

He said further "I have developed an important variation which must be mentioned—but I do so with some hesitation," and he urged his inexperienced colleagues to follow the stages described in his first paper "with the beautiful landmarks as their constant guide"

This variation consists in making an inverted U-shaped flap of meatal skin covering the outer attic wall and in detaching the drum only in the area corresponding to Rivinus' incisure—i e, just as I have done for the past year

It is also interesting that Popper now removes the periosteal bone layer of the cupola in the same way that I have suggested

I have been somewhat afraid that the cell system of the mastoid process might become infected in connection with the operation or subsequently In the first case, therefore, roentgenologic examination of the temporal bone was performed before as well as some time after the operation Only in 2 of 38 cases did roentgenography show a slight postoperative dimness of the mastoid cells The 2 patients were operated on again because the meatus became constricted A conservative radical operation was performed The periantral cells and the cells of the mastoid tip were found to contain insignificant amounts of granulation tissue, which was undergoing organization, otherwise there were no inflammatory phenomena in the mastoid process It is to be added

4 Popper, O F J Laryng & Otol 61 441 (Aug) 1946

that such a conservative radical operation had to be performed on account of meatal constriction also in a case in which no inflammatory phenomena were found. In all 3 cases the improvement of the hearing was maintained.

#### MISHAPS

The following accidents have happened with this operation.

In 1 case the facial canal was denuded under the chiseling of the lateral attic wall, which resulted in facial paralysis of brief duration. In another case facial paralysis appeared five days after the operation and lasted a few weeks. The cause of this transitory paralysis could not be found.

In the first 4 cases in which I performed this operation, as mentioned before, the vestibular function was abolished in part, presumably on account of insufficient caution in the employment of the suction apparatus. In some additional cases the vestibular function was lowered but not abolished. For some little time the first 4 patients were troubled with dizziness and uncertainty of balance.

In 6 of the first 20 cases in which I myself or my assistants operated we had the misfortune to perforate the tympanic membrane. On the other hand, among the remaining 70 cases there was only 1 in which perforation occurred. The perforated membranes closed in all cases except 1. Perforation of the tympanic membrane causes considerable impairment of hearing. After healing of the perforated membrane the improvement due to the fenestration becomes the same as in cases without perforation.

Unfortunately, in 3 cases the meatal flap was torn entirely away from the tympanic membrane. In 2 of these cases it was placed in situ above the fenestra as a free graft, while in the third a Thiersch graft was laid. In 1 of these patients a chronic defect of the tympanic membrane resulted and there was no improvement of hearing. In the remaining 2 patients the perforated tympanic membranes healed, and the healing was followed by improvement of hearing. It is interesting to note that in the case in which transplantation was undertaken according to Thiersch the improvement of hearing still persisted after five months.

In 1 case the entire lateral membranous semicircular canal was removed by an unfortunate manipulation. This did not eliminate the caloric reaction, nor did it affect the cochlear portion of the ear. There was improvement from hearing at 0.40 meter to hearing at 16 meters for normal speech on examination two months after the operation. The case is of considerable interest from an experimental point of view, since it shows that with the modern chemotherapeutic agents being used as adjuvants, one can remove a single membranous semicircular canal without injuring the rest of the labyrinth. A further account of

this case is given in a subsequent article Helmer Rasmussen's, entitled "Vestibular Function Prior to and Following Operation for Otosclerosis"

We have so far operated on 90 patients, using Popper's method. In 2 patients only was the operation followed by increased hardness of hearing, the hearing for normal speech having been reduced from 0.10 meter to *ad aurem*. This result shows the risk of impairment of the hearing to be so small that it can be left out of account in practice. Consequently, I intend in the future to operate on the ear with the best hearing when this is judged to be particularly profitable, and not, as usually, on the ear with the poorest hearing.

I have dwelt on the mishaps which we have experienced during our operations, and it appears from what has been stated so far that they are by no means discouraging. It is to be especially noted that infection of the labyrinth occurred in none of our patients. However, it should always be borne in mind that any surgical intervention involves a risk. We know from the literature that—very rarely, indeed—death has been recorded in consequence of the operation, even though the surgical intervention cannot be said to have been the direct cause of death. We have ourselves had a severe case. A pulmonary infarct developed during the postoperative confinement in bed, probably in consequence of phlebitis and, in addition, acute pyelonephritis and uremia. The patient recovered completely, however, after a long illness.

#### COMMENT ON RESULTS

Since a fairly long period of time must elapse after the operation before it is possible to pronounce with certainty on the final results with regard to the hearing, only a rather small number of the cases in which we operated can be used for an estimation of the results. This phase of the problem will be considered by Dr. Harald Ewertsen. Here it may only be mentioned that if we consider the fistula to be open when a positive fistula sign can be demonstrated, or if, when there is no fistula sign, real improvement of hearing has been demonstrated through the different acoustic tests, the fistula has, so far, become closed only in 7 of these 90 cases. This appears from table 1, comprising 62 patients on whom we have obtained information concerning this fact either in examinations made by one of us within a month or so prior to the time of writing or in other ways.

The table shows that 29 patients present a fistula sign and improved hearing, while 21 patients have improved hearing despite a failure to present a fistula sign, i. e. the fenestra has not closed. Five patients present a positive fistula sign but have nevertheless obtained no improve-

ment of hearing Four of these were unfit for operation prior to surgical intervention, having had an aural range for normal speech of less than 0.10 meter Seven have no fistula sign and unchanged hearing, in 2 hearing is even impaired Thus the fenestra is open in 55 of 62 cases, i. e., in 89 per cent

Results in 30 cases followed up for more than six months after the operation are recorded in table 2 (in 11 more cases we have no recent information)

It appears from table 2 that 25 of the 30 patients have an open fenestra Thus 83 per cent have had an open fenestra for more than six months since the operation (Of the 11 patients just mentioned, probably 8 or 9 have an open fenestra)

TABLE 1—Results in 62 Patients Examined One to Thirteen Months After Operation

	Fistula Test Positive	Fistula Test Negative	Total
Hearing improved	29	21	50
Hearing not improved	5	7	12
Total	34	28	62

TABLE 2—Results in 30 Patients Examined Six Months or More After Operation

	Fistula Test Positive	Fistula Test Negative	Total
Hearing improved	12	10	22
Hearing not improved	3	5	8
Total	15	15	30

# SUMMARY

An account is given of the technic of Popper's operation for otosclerosis as described in the *Journal of Laryngology and Otology* in 1946

This operation, in which the initial incision is made anterior to the external auditory meatus, has been carried out on 90 patients with the following modifications of Popper's original technic

- 1 The skin lining the wall of the anterior part of the bony meatus is preserved, the integuments being detached from the tympanic portion prior to the removal of the latter and subsequently used as a plastic flap

- 2 The skin flap from the posterior bony meatal wall (the "meatal flap") is made far smaller than that recommended by Popper, being made 1 cm long only above and posteriorly, and much narrower downward in the posterior meatal wall and forward in the superior meatal wall Only by introducing these modifications can one be sure to avoid postoperative narrowing of the external auditory



meatus, a narrowing which may easily cause retention in, and possibly inflammation of, the mastoid cells

3 The tympanic membrane is not detached to the extent indicated by Popper, but only over the area of the incisura Rivini including the posterior tympanic spine

4 The lateral bony attic wall is removed in the following way. A hole is cut with a 2 mm burr through the middle of the attic wall. Next the "bridge" thus developed is chiseled away. The hole in the attic wall is made larger with chisel and rongeurs. (The varying anatomic conditions of the lateral attic wall are described)

5 The cutting of the fenestra in the vestibular dome is not carried out as indicated in Popper's original publication but according to Shambaugh's method ("enchondralization"). The meatal flap is kept in situ after the operation by means of a strip of gauze soaked in sulfathiazole-penicillin-Ringer's solution (10 cc of Ringer's solution containing sulfathiazole sodium, 0.5 Gm, and penicillin, 1000 Oxford units per cubic centimeter)

After the operation the patient is placed in the head supporter recommended by Shambaugh, with the head upright

The advantages of the transtympanic over the transmastoidal operation are discussed

1 The tympanomeatal flap can be detached easily and quickly, without wasting time by thinning and breaking down the posterior bony meatal wall

2 The tympanic membrane is detached to a small extent only

3 One gets a "square-on" view of the site of fenestration in the vestibular dome

4 The facial canal stands out clearly

5 The mastoid process is left intact

6 It is unnecessary to remove the head of the malleus

For these several reasons the operative trauma of Popper's procedure is far smaller than that of Lempert's operation. The Popper technic can be carried out more quickly and easily. There is no risk of infection of the cell system of the mastoid process when the skin of the mastoid process is treated as indicated in this article.

Among 90 operations carried out within the period between November 1946 to March 1948 there were only 2 failures with increased impairment of hearing. The fenestra has remained open in 89 per cent of the cases. Among the patients followed up more than six months after the operation 83 per cent have an open fistula. The results of investigations of the acoustic and the vestibular function carried out before and after the operation will be reported in the following articles by Dr. Helmer Rasmussen and Dr. Harald Ewertsen, respectively.

## II ACOUSTIC FUNCTION BEFORE AND AFTER OPERATION FOR OTOSCLEROSIS

HARALD EWERTSEN, M D

**A**N INVESTIGATION of the acoustic function is essential in the diagnosing of otosclerosis. In the present paper an account is given of tests made with tuning forks, monochord, whispered voice and speech as well as with the audiometer and possibly Fowler's test. None of these functional tests are ideal, and discrepancies are often experienced between the various tests.

Tuning forks and the monochord are not quite satisfactory when patients with impaired hearing are concerned.

Trowbridge,<sup>1</sup> who has for several years been doing routine hearing tests in the United States Army, using both tuning forks, speech and audiometer, stated that tuning forks can be usefully applied only with intelligent persons, but "the results were often confusing and contradictory, and precise conclusions could not be made from them alone."

The monochord is of importance for the fixing of the upper tone limit. Hall<sup>2</sup> holds that the assessment of the upper tone limit obtained by measuring bone conduction with the monochord "is a useful indication of the probability or otherwise of success" in the selecting of patients for operation, a fact which has been corroborated through our investigations.

Speech hearing tests, as Holmgren<sup>3</sup> pointed out, give great variations, many different factors being involved, such as the acoustic conditions of the room, the vocal pitch of the examiner, and the psyche and disposition of the patient. Practice and guessing will, moreover, play a part in repeated hearing tests, so that an apparent improvement may be noticed.

Fowler<sup>4</sup> maintained that the distance at which whispered voice or speech can be heard may present variations of up to 200 per cent, because among other reasons, the examiner is apt, quite unconsciously, to raise his voice at increasing distance from the patient.

Some of these difficulties have been overcome by using gramophone records for the hearing tests, with which the loudness of the reproduction of whisper or speech can be exactly regulated. However, this method also has certain disadvantages. The reproduction is not true to nature, the records become worn, and on repeated tests the patients will gradually learn the test words and their order of succession.

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1 Trowbridge, B C. Correlations of Hearing Tests, *Arch Otolaryng* **45** 319 (March) 1947.

2 Hall, S I. *J Laryng & Otol* **60** 201, 1945.

3 Holmgren, G. *Nord med (Hygiea)* **100** 681 and 757, 1938.

4 Fowler, E P. Simple Method of Measuring Percentage of Capacity for Hearing Speech. Fundamental Factors in Setting up a Standard, *Arch Otolaryng* **36** 874 (Dec) 1942.

Fowler<sup>4</sup> has ascertained that one need not distinguish each individual sound to be able to understand ordinary speech. To hear 70 per cent of the articulation is quite enough to catch the sense. To fulfil this requirement, ordinary speech must reach the ear with an intensity of not less than 30 decibels above the threshold value. It may, therefore, be understood that in a patient with impaired hearing a gain of 10 decibels is sufficient to change a number of incoherent sounds into intelligible speech.

It is a common experience that there is often a discrepancy between the audiogram and the result of the speech test. Thus, for instance, Kinney<sup>5</sup> wrote that the degree of impairment of hearing found by audiometry need not correspond to that ascertained at the speech test, because pure tones (= audiometer) are not heard any better binaurally than with the best ear alone, whereas spoken voice is heard better binaurally than with the best ear only.

In audiometry the weakest audible intensity of a pure tone is registered, and the curve indicates the threshold of hearing but gives no information on that which is of the greatest importance for the patient's social adequacy, namely, his acuity of hearing above the threshold. Two persons with similar threshold audiograms may not hear speech alike. This is due to the recruitment phenomenon present in patients with nerve deafness but not in patients with a lesion of the conductive system. Fowler gives an instance of 2 patients, both with a threshold audiogram showing a loss of 40 decibels. Supposing that one patient has conductive deafness—he will not be able to understand speech till the intensity is 70 decibels, i.e., 30 decibels above the threshold, whereas the other, if he has nerve deafness, will be able to understand speech at 54 decibels, owing to the regression or recruitment.

The audiogram has so far given the best objective measure of changes of hearing acuity when the determination is made with the same apparatus and in the same noise-free room, and is carried out by an experienced examiner. There is, however, no doubt that the patient's experience and disposition influence the result. Harris,<sup>6</sup> by making repeated audiometric tests on a great number of patients, found the accuracy to be within 4.3 to 4.0 decibels at frequencies from 512 to 2048.

In otosclerosis the impairment of hearing is—as is well known—due to two different factors, a conductive factor and a perceptive lesion, depending as it does partly on the stapedial ankylosis and partly on an impairment of function of the end organ of hearing. The ankylosis has by far the greater share in the impairment of hearing, so that the audiogram presents a considerable difference between air conduction and bone conduction.

For prognostic purposes it is important that the value of the bone conduction, as an expression of the function of the cochlea, be ascertained, since by operation no greater improvement of the air conduction can be obtained than that corresponding to the existing degree of bone conduction. However, Lempert<sup>7</sup> pointed out that neither the bone conduction values found with tuning forks nor those obtained with the audiometer give fully reliable measures for the function of the end organ of hearing, partly because of transmission of sound to the better ear and partly because of recruitment.

5 Kinney, C. E. *Laryngoscope* **55** 117, 1945.

6 Harris, J. D. *Free Voice and Pure Tone Audiometer for Routine Testing of Auditory Acuity. Studies on Comparative Efficiency*, *Arch. Otolaryng.* **44** 452 (Oct.) 1946.

7 Lempert, J. *Lempert Fenestra Nov-Ovalis with Mobile Stopple*, *Arch. Otolaryng.* **41** 1 (Jan.) 1945, cited by Fowler, E. P. *Otosclerosis. An Index of Literature, with Abstracts, for 1944-1945*, *ibid.* **45** 215 (Feb.) 1947.

Walsh and Silvermann<sup>8</sup> likewise hold that bone conduction is no reliable expression of cochlear function, because the thickness of the bone, the degree of its pneumatization and the condition of the mucosal lining influence the degree to which sound waves are conducted through the bone ("Bone conduction tests in many cases are unreliable. We pay little attention to them and use them only for general screening.")

The conclusion is that there is not yet an exact test for acoustic function to indicate the degree of the auditory nerve's degeneration, so that—on the assumption of a technically successful operation—one cannot yet settle the prognosis with regard to the patient's postoperative acuity of hearing. Holmgren<sup>9</sup> has given an illustrative example. The patient prior to operation presented a bone conduction threshold of 70 decibels and an air conduction threshold of 90 decibels at the frequency of 2000 cycles, and accordingly there would seem to be contra-indication for operation. However, the patient presented a postoperative improvement of the bone conduction threshold to 5 decibels and of the air conduction threshold to 35 decibels, and the patient had obtained hearing for speech at a distance of 10 meters, compared with *ad aurem* hearing two years previously.

#### MATERIAL

The observations to be reported were made on the first 85 patients operated on in the ear department of the Sundby Hospital, Copenhagen, beginning Nov. 8, 1946—within about seventeen months prior to the time of writing.

The diagnosis of otosclerosis and the selection of the patients were based on the following criteria: past history, otoscopic examination, investigation of acoustic and vestibular functions, roentgenographic study. In estimating the material it should be borne in mind that the indications for operation were not particularly strict, because (1) the risk of further impairment of hearing is small, (2) the ear with the poorest hearing acuity has always been operated on, and (3) patients, even those with excessive hardness of hearing, have a chance of obtaining considerable improvement of hearing acuity.

Of the 85 patients, one third were men and two thirds were women, a sex incidence which accords with that of other statements.

The ages of the patients ranged from 22 to 67, with an average of 45 years.

The defect of hearing had persisted for from five to forty-five years, and had first been noticed by the patients at some time within the period from the age of puberty till about the end of the thirties, in most cases within the twenties. About 60 per cent of the patients had used a hearing aid prior to the operation.

#### OBSERVATIONS

*Paracusis*—In addition to hardness of hearing and tinnitus, numerous otosclerotic patients report a subjective phenomenon called *paracusis willisiana*, which means that the patient's hearing is better in noise (e. g., train, tram or factory) than under quiet conditions.

<sup>8</sup> Walsh, T. E., and Silvermann, R. S. *Laryngoscope* 56: 536, 1946.

<sup>9</sup> Holmgren, G. *Nord. med.* 37: 151, 1948.

This is, according to Voss,<sup>10</sup> due to a thiotropy, i. e., the power of certain gels to be liquefied by intense shaking, after which they return to their original consistency. Wood<sup>11</sup> succeeded in making thiotropic gels liquid by the action of sound waves of high frequency.

Fifty-eight of the patients were questioned about this symptom. Thirty-four answered in the affirmative, while 24 had observed no such symptom. In other words, 59 per cent of these patients had experienced paracusis. This is, therefore, a rather important symptom, the more so because all other forms of deafness are extremely rarely found associated with paracusis.

*Diplacusis*—Among 38 patients questioned 1 patient stated that diplacusis (for deep tones only) had been noted.

*Tinnitus*—This is a symptom commonly associated with otosclerosis. Only 8 of 70 patients had never had a subjective noise in the ears. Lempert stated that tinnitus ceased in 95 per cent of his suc-

TABLE 1—*Tinnitus*

Prior to Operation—70 Patients	Following Operation—53 Patients
25, pronounced tinnitus	28, unchanged tinnitus
37, varying or light tinnitus	15, cessation of tinnitus *
8, no tinnitus	6, reduced tinnitus
	4, aggravated tinnitus

\* Tinnitus ceased in 15/53, or 29%

cessful operations. Among the present patients the tinnitus was as shown in table 1.

*Acuity of Hearing*—Acuity was assessed on the basis of whisper and voice tests, audiometry, tuning-forks and monochord tests and the patients' own statements.

There are many ways in which to estimate acuity of hearing. I shall point out here only the most important.

It is the patient's hearing of speech which is the decisive factor for his social adaptation. Moreover, the speech test has proved, despite its drawbacks, to give a serviceable measure of the patient's loss of hearing.

The room in which the tests were performed was 15 meters long and had a somewhat varying noise level. The voices of the different examiners gave varying results, yet the variation was within fairly narrow limits, so that classification of the patients was possible (see table 2). In order to counteract the unconscious inclination to raise

10 Voss, O. Med. Welt **13** 1011, 1939, cited by Fowler, E. P. Otosclerosis. An Index of the Literature with Abstracts, for 1944-1945, Arch. Otolaryng. **45** 215 (Feb.) 1947.

11 Wood, cited by Voss.<sup>10</sup>

the voice at increasing distance from the patient, I performed each test with closed eyes and concentrated on speaking in the same intensity of voice throughout

Of the 85 patients, 69 have been kept under observation for from one to thirteen months since the operation. The speech tests gave the results indicated in table 2. Two showed slight deterioration (from 3 to 1 meter and from 0.20 to 0.10 meter), in 11 hearing was unchanged, in 16 hearing was somewhat improved and in 40, i. e., 58 per cent, hearing was definitely improved ( $V \geq 4$  meters).

Within the group capable of hearing voice at a distance of 10 cm or less only 18 per cent obtained definite improvement. Hence this upper group must be regarded as unfit for fenestration.

TABLE 2—Results of Speech Tests of 69 Patients Made Before and After Fenestration \*

Hearing Distance Before Operation	Patients	Hearing Distance After Operation								Proportion of Patients Definitely Improved
		Ad. Aures to 0.10 M	0.20 M	0.50 M	1.2 M	4 M †	8 M	12 M	>15 M	
Ad. aures (shout)	1			1						0 of 1
Ad. aures to 0.10 M	21	2	8	5	2	2	1	1		4 of 21
At 0.20 M	23	1	2	1	3	3	5	1	7	16 of 23
At 0.50 M	11				2			4	5	9 of 11
At 1.00 M	3				1		1		1	2 of 3
At 2.00 M	4						3		1	4 of 4
At 4.00 M	1				1					1 deteriorated
At 8.00 M	5							3	2	5 of 5
Total	69	3	10	7	9	5	10	9	16	40 of 69 = 58%

Age Incidence

In the upper group 13 of 43 = 30 per cent were under 45 years old  
 In the lower group 19 of 26 = 73 per cent were under 45 years old

\* The periods of observation ranged from one to thirteen months

† Bold face figures indicate safe improvement

The age incidence bears out the theory that otosclerosis is a disease which progresses with increasing age. Thus, the patients of the group proving to have been the least fit for operation were also the oldest. If we set the limit at the average age of 45 years, only 30 per cent were under 45 years of age in the upper group, against 73 per cent in the lower group.

If stricter limits had been set for the indications for operation and the least fit group, comprising 22 patients, had been excluded, 47 patients would have been left, of whom 36, i. e., 77 per cent, obtained definite improvement.

This again means that hearing for speech is not a bad indicator of the result to be expected from operation. If the patient has hearing for voice at 10 cm or less ( $V \leq 10$  cm), there is only 18 per cent chance of definite improvement, whereas there is 77 per cent chance of

definite improvement when there is hearing for voice at 20 cm or more ( $V \geq 20$ )

On the other hand, hearing for voice at 10 cm or less is no contraindication for operation, some patients obtaining considerable improvement of hearing. I have therefore tried to find out whether any of the other hearing tests can give a hint as to the prognosis. Table 3 presents the average determinations for 22 patients with preoperative hearing for voice at 10 cm or less. Of these patients,

TABLE 3—Results of Preoperative Tuning Fork, Fowler and Monochord Tests of 22 Patients with Preoperative Hearing for Voice at 0.10 Meter or Less

Group	Average Age	Tuning Fork Test		Fowler's Test		Monochord Test	
		Air a <sub>1</sub>	Bone a <sub>1</sub>	Bone	Air	Air	Bone
11 patients with hearing improved to $V = 7$ M	48	4"	13"	55 db	90 db	0	16,000
11 patients with unimproved hearing	52	3"	14"	56 db	88 db	0	10,000

The third column shows the average vibration time in seconds for tuning fork a<sub>1</sub>, measured partly by air conduction and partly by bone conduction (normal = 60" and 30")

The fourth column contains the average decibel values calculated according to Fowler partly by bone conduction and partly by air conduction

In the last column the average values have been set out for the upper tone limits by air conduction and by bone conduction, measured with the monochord

TABLE 4—Results of Speech Tests of 30 Patients Six to Thirteen Months After Fenestration

Preoperative Hearing Distance	Patients	Ad Aurem to 0.10 M	Postoperative Hearing Distance							Safe Improvement
			0.20 M	0.50 M	1.2 M	4 M *	8 M	12 M	15 M or More	
Ad aurem to 0.10 M	10	5	1				1	1	2	4 of 10
0.20 M	9		1		1	1	1		5	7 of 9
0.30 M	5			1	1			1	2	3 of 5
1 m 3 M	3				1		1		1	2 of 3
4.00 M	1								1	1 of 1
8.00 M	2								2	2 of 2
Total	30									19 of 30 = 63%

\* Bold face figures indicate safe improvement

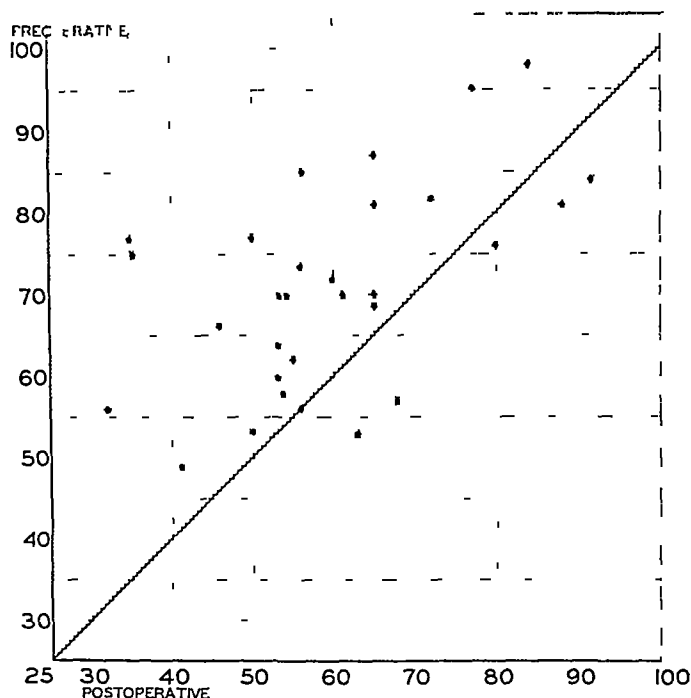
11 obtained more or less improvement of hearing (averaging  $V = 7$  M) while in the remaining cases the hearing remained unchanged or was slightly worse

The two groups were compared with regard to age, hearing acuity measured with tuning fork a<sub>1</sub> and the bone and air conduction values obtained with monochord and audiometer. The values for the lower limit were difficult to calculate, but they seem to have been identical in the two groups

Only the average values have been recorded in table 3. It appears from these figures that the two groups of patients presented no dif-

ferences with regard to average age, hearing acuity measured with tuning fork  $a_1$  or level of audiometer curves. But the preoperative value for the upper tone limit of bone conduction measured with monochord was essentially higher for the group of improved patients than for the patients who obtained no improvement of hearing. This observation bears out Hall's previously mentioned experience.

Forty-one patients were operated on more than six months ago. We still have contact with 30 of these patients. In 1 patient hearing has slightly deteriorated, in 8 hearing is unchanged, in 2 hearing is slightly improved, in 19 *i. e.*, 63 per cent, hearing is definitely improved.



Air conduction values of 30 patients according to Fowler's test. The ordinate indicates the preoperative value in decibels, and the abscissa the postoperative value measured from six to thirteen months after the operation. Eighteen of the 30 patients, *i. e.*, 60 per cent, have obtained improved hearing.

By leaving out again the least fit group, comprising 10 patients, with a hearing for speech less than 0 10 m, there are 20 patients left, of whom 15, *i. e.* 75 per cent, obtained definite improvement.

The fistula sign changed in 7 patients from positive to negative in the course of from six to thirteen months after the operation, but in 3 of these the acuity of hearing is still improved. This means that the fistula closed within six to twelve months after the operation in 4 of the 30 patients, *i. e.* 13 per cent. By way of comparison the percentages reported by some others may be stated. Lempert had 140 among 1,000 (14 per cent), Shambaugh 51 among 800 (6.5 per cent), Day 10 among



100 (10 per cent), of whom 9 were among his first 50 patients (18 per cent)—in other words, figures corresponding to those of the present group

In the chart I have set out in diagrammatic form the air conduction values calculated according to Fowler's test

The audiometer in the Sundby Hospital is a radiometer® product of rather fine calibration. Three examiners have each studied 7 young persons in whom otoscopic examination showed normal conditions and have generally found thresholds of about 5 to 10 decibels where the thresholds ought to be on the zero line. The results of our measurements have to be corrected upward by about 10 decibels to correspond with the measurements of other authors

All the values grouped about the axis at a distance of up to  $\pm 5$  decibels are regarded as unchanged (10 patients). In 2 cases the values lie somewhat below the axis, thus showing slight deterioration. Eighteen

TABLE 5—Shifts of Tone Limits

		Fenestra		Total
		Open	Closed	
Shift of lower tone limit	up	1		1
	unchanged	3		3
	down	9	2	11
Total		13	2	15 patients
Shift of upper tone limit	up	7 (2)	1	8 (3)
	unchanged	2		2
	down	11 (2)	3	14 (5)
Total		20 (4)	4	24 (8) patients

ie 60 per cent, whose values lie above the axis, have obtained improved hearing. Thus, there is agreement between the results obtained by audiometry and those obtained by speech tests. However, none of these patients has achieved a threshold of hearing better than 30 decibels by air conduction.

The bone conduction values before and after operation have in these 30 cases remained fairly constant within the range of error of  $\pm 5$  decibels. But in 4 cases an improvement was shown in bone conduction of from 14 to 20 decibels. The requirement often made by American investigators of a preoperative bone conduction threshold better than 30 decibels within the speech range is in our opinion too strict, this requirement having been fulfilled by only one of the patients here reported on.

Moreover, mention will be made here of the shifts of upper and lower tone limits. The shift of the lower tone limit following the operation was controlled in 15 cases. In 1 it was raised (from 30 to 65 cycles), in 3 it remained unchanged, and in 9 it was depressed, in some of them as far down as 16 cycles.

The shift of the upper tone limit was controlled with the monochord in 24 cases and compared with the improvement of hearing and the fistula sign. Shambaugh found no depression in his material, and he holds that depression of the upper limit is indicative of serous labyrinthitis, affecting chiefly the upper tone limit.

Holmgren, on the other hand, regards a depression of the upper tone limit as due to reduced intralabyrinthine pressure.

In the present series the upper limit had become raised (measured either by bone conduction or by air conduction) in 8 cases and depressed in 14, it remained unchanged in 2. The percentage distributions of hearing improvement and fistula sign are alike for these groups.

I shall finally conclude this article with mentioning that Rinne's test was controlled after the operation in 19 of 69 cases. In 12 cases it still showed that bone conduction was better than air conduction. One explanation for this, among others, is that not only the air conduction but also the bone conduction at this frequency had been prolonged by the operation. For the remaining 7 patients the Rinne test showed that air conduction was better than bone conduction.

### III VESTIBULAR FUNCTION PRIOR TO AND FOLLOWING OPERATION FOR OTOSCLEROSIS

HELMER RASMUSSEN, M D

IN THE present article the results of vestibular investigations will be presented for 79 of the 88 patients operated on for otosclerosis according to Popper's method in the ear department of Sundby Hospital between November 1946 and April 1948

Of the 79 patients, the majority, 51, were in their thirties and forties, while 5 were in their twenties, and 23 in their fifties and sixties. Thirty-one were men, and 48 were women

#### VERTIGO

Concerning 67 the presence or absence of vertigo prior to operation was known, 18, i e., 27 per cent, had been suffering from more or less pronounced vertigo. This figure accords with Nager's<sup>1</sup> findings. Of his patients, one fourth to one third complained of vertigo, without physical vestibular disturbances being demonstrable

After the operation 15 patients were completely free from vertigo, while in the remaining 64 patients more or less disturbing vertigo persisted for a shorter or longer time, as appears from table 1

In 7 of the 13 patients with protracted vertigo the symptom was still present at the latest follow-up. Those with protracted vertigo belong chiefly to the first half of this series, a fact which indicates that the technic used has gradually improved

#### SPONTANEOUS NYSTAGMUS

Spontaneous nystagmus was demonstrated following the operation in all cases except 4. The duration of the nystagmus appears from table 2. The direction of the nystagmus was exclusively toward the normal side in 35 cases and exclusively toward the side operated on in 1 case. In the remaining cases the direction varied between the normal side and the side operated on—or the nystagmus was undulatory. The direction would often change within the same day

Brunner,<sup>2</sup> on the other hand, arrived at a different result so far as he found that the eyeballs rolled toward the side not operated on

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1 Nager, F R., in Fowler, E P. *Medicine of the Ear*, New York, Thomas Nelson & Sons, 1939, p 261

2 Brunner, H., and Cutler, M H. *Labyrinthine Symptoms Subsequent to Fenestration of Labyrinth*, Arch Otolaryng **45** 613 (June) 1947

within the first twenty-four hours after operation but that after twenty-four hours the nystagmus changed, being either directed toward the side operated on or undulatory. The nystagmus would generally subside in the course of three or four days.

In some cases, after spontaneous nystagmus was no longer observed with the patient in the dorsal or the upright position, nystagmus could be demonstrated when the head was bent sideways or forward or backward. However, no great importance should be attached to this phenomenon, as it was no doubt a vascular fistula sign in several of the cases.

#### NYSTAGMUS PRODUCED BY FISTULA TESTS

Fistula tests were made on all the patients except 2, partly by pressing directly against the site of the fistula and partly by compressing and

TABLE 1—*Vertigo After Operation (79 Patients Investigated)*

Duration of Vertigo	Patients
No vertigo	15
1 to 3 days	24
4 days to 2½ wk	27
1 to 15 mo	13
Total	79

TABLE 2—*Spontaneous Nystagmus After Operation (79 Patients Investigated)*

Duration of Nystagmus	Patients
No spontaneous nystagmus	4
1 to 7 days	43
1 to 4 wk	27
1 to 6 mo	5
Total	79

decompressing the air of the external meatus with a bulb. Furthermore, examinations were made for the vascular fistula sign by compressing the jugular veins from the right and from the left side alternately, as well as from both sides simultaneously, and after inhalation of amyl nitrite. Finally, fistula tests were made during the first few days after the operation, i. e., before the dressing was changed, by pressing against the dressing.

The fistula test was generally made the first time the dressing was changed, and then repeated at regular intervals.

The results of the tests appear in table 3. In 2 cases the fistula sign was not looked for. In 13 cases all fistula tests gave negative results, while in 7 cases the fistula sign could be produced only during the first few days after the operation by pressing against the dressing, whereas the rest of the fistula tests gave negative results.

Furthermore, it appears that if the fistula has not closed after six months, the chance of its remaining open is great, as the fistula closed in only 1 of the 17 cases in which more than six months had elapsed after the operation

A comparison between direct pressure and compression made in the external auditory meatus for eliciting the fistula sign showed the sign to be positive longest by comparison in 16 cases and longest by direct pressure in only 1 case

The direction of the nystagmus appears from table 4. In all cases the nystagmus was lateral or lateral-rotary, or mixed lateral and lateral-rotary, but never rotary alone. It may be added that the fistula sign was regular in all the 7 cases in which the sign could be elicited only by

TABLE 3—*Fistula Sign After Operation*

Number of Months After Operation	Patients in Whom Sign Was Still Present	Patients in Whom Sign Later Disappeared	Total
$\frac{1}{4}$ to $\frac{1}{2}$	8	}	20
$\frac{1}{2}$ to 2	7		20
2 to 6	15	5	17
6 to 15	16	1	17
Total	46	11	57

TABLE 4—*Directions of Nystagmus at Fistula Tests*

Test	Patients Presenting Given Type of Nystagmus		
	Regular	Reverse	Mixed
Pressure directly over fenestra	40	2	10
Compression in external canal	38	4	10
Decompression in external canal	26	7	8

pressing against the dressing, (i e, during the first days after the operation)

In a few cases the direction of the nystagmus differed with the different methods of testing. Thus, direct pressure elicited regular nystagmus and compression in the external meatus elicited reverse nystagmus in 3 cases, whereas the opposite directions were seen in 2 cases. In 6 cases the eyeballs rolled toward the side operated on both with compression and with decompression. In 3 of these the eyeballs later rolled toward the side operated on with compression and toward the opposite side with decompression. The reverse phenomenon (i e, nystagmus toward the side not operated on both with compression and with decompression) was not observed.

In 76 cases tests were made for the vascular fistula sign by compression of the jugular veins, and in 13 cases, by inhalation of amyl nitrite

Compression of the jugular veins produced a fistula sign in 30 of the 76 cases, and amyl nitrite, a positive sign in 6 of the 13 cases. This result contrasts with that arrived at by Brunner,<sup>2</sup> who in none of 24 cases of fenestration demonstrated a vascular fistula sign by pressing against the carotid artery.

The sign was in no case positive on compression of the jugular veins and negative on inhalation of amyl nitrite, whereas the reverse was observed in 5 cases.

On compression of the jugular veins the sign was regular (i. e., the nystagmus was directed toward the side not operated on) in 9 cases and reverse (i. e., the nystagmus was directed toward the side operated

TABLE 5—*Direction of Nystagmus on Compression of Jugular Veins and Inhalation of Amyl Nitrite*

Test	Patients Presenting Given Type of Nystagmus			
	Regular	Reverse	Mixed	Undulatory
Compression of jugular veins (30 patients)	9	13	7	1
Inhalation of amyl nitrite (6 patients)	1	5		

TABLE 6—*Duration of the Vascular Fistula Sign as Observed in the 30 Patients in Whom It Was Obtained by Compression of the Jugular Veins*

Number of Months After Operation	Patients in Whom Sign Was Still Present	Patients in Whom Sign Later Disappeared	Total
Up to 2	7	8	15
2 to 6	8	2	10
6 to 10	5		5
Total	20	10	30

on) in 13, in 7 it was alternately regular and reverse, and in 1 case the nystagmus was undulatory. In other words, the fistula sign was reverse or alternately regular and reverse in two thirds of the cases (table 5).

The amyl nitrite sign was in 1 case regular (i. e., the nystagmus was directed toward the side not operated on) and in 5 cases reverse (i. e., the nystagmus was directed toward the side operated on) (table 5).

The amyl nitrite test was performed only once on each of the examined patients. The reason for this as well as for the fact that the test was not made on the remaining patients was simply that no more amyl nitrite could be procured.

The jugular vein test, on the other hand, was made several times. The results of these repeated tests appear from table 6. It is seen that in several patients the sign was still positive long after the operation at a point of time when the area of operation had healed completely and

when, accordingly, no granulation tissue could be expected to be present in the fistula. Therefore the sign can hardly have been due to changes of volume because of hyperemia of granulation tissue here, but must have been due to changes of pressure in the labyrinth because of increased volume of blood in the latter or to intracranial changes of pressure affecting the labyrinth by way of the saccus endolymphaticus.

#### NYSTAGMUS PRODUCED BY ROTATION

Two patients were not submitted to rotation tests prior to the operation. On 28 patients the preoperative tests were made only with the patient in the upright position, while on the remaining 49 the tests were made with the patient in the upright position and with the head bent to the right and to the left, as well as forward and backward.

One patient was not submitted to rotation tests after the operation. Postoperative rotation tests were made on the remaining patients with the head in the different positions. In 45 cases the tests were performed first one to two weeks after the operation, in 20 cases two to three weeks, and in 13 cases three weeks to five months after the operation.

In each position five rotations were carried out to each side within about ten seconds.

*Rotation with the Patient in Upright Position*—Prior to Operation. It is a matter of no small interest that in 6 patients the postrotatory lateral nystagmus was of short duration, less than ten seconds, prior to the operation. In one of these patients abnormal conditions were demonstrated also for the postrotatory rotary and vertical nystagmus. In another patient the duration was sixteen seconds to one side, but forty-nine seconds to the other—in other words, a difference of more than 50 per cent.

The foregoing facts show that the vestibular apparatus was affected in these 7 patients. This is only what might be expected, since well over one fourth of the entire series reported subjective vestibular disturbances, namely, vertigo.

*After Operation*. In 12 patients with normal duration of the postrotatory lateral nystagmus prior to the operation there was now found a duration of less than ten seconds for the postrotatory lateral nystagmus released from the side operated on. However, in none of these patients was the duration of the nystagmus released from the side operated on less than half of that released from the side not operated on, which was likewise short, twelve seconds at most.

These findings suggest that there is reduced function of the horizontal canal on the side of operation, due to a minor damage in consequence of the operation. Likewise, it is suggested that compensation has occurred on the side not operated on.

In 8 patients, 7 of whom were examined one to three weeks and the eighth two and a half months after the operation, the duration of the nystagmus released from the side operated on was found to be less than half of that released from the side not operated on, and the longest duration was eleven seconds. In 3 of these patients no nystagmus whatever was released from the side operated on. One of the 8 patients was the one previously described in whom prior to the operation nystagmus was released from the ear to be operated on for sixteen seconds and from the other ear for forty-nine seconds, a fact which is suggestive of reduced function of the horizontal canal. Following the operation, the durations were five and thirty-two seconds, respectively, showing complete loss of function of the canal.

In 9 more patients the duration of the nystagmus released from the ear operated on was found to be equal to or under half of that of the nystagmus released from the other ear. As, however, these patients presented spontaneous nystagmus toward the side not operated on, the lack of response to rotation stimulus of the labyrinth on the side of operation cannot be regarded as definitely pathologic.

Thus, in only 8 cases can the horizontal canal be said for certain not to have responded to the rotation stimulus.

Subsequent tests showed the postrotatory reaction to have become normal in 6 of these 8 cases. In the seventh nystagmus was released only for six seconds from each side. Thus compensation had occurred on the side not operated on. In the eighth case the membranous horizontal canal had been removed during the operation, and in this case no reaction could be elicited from the side of operation, neither at the first nor at the second test which was made on the fiftieth day after the operation. Compensation occurred here, too, since the nystagmus released from the side not operated on lasted twenty-five seconds at the former test and only five seconds at the latter. Here we have a purely experimental corroboration of the laws concerning the post-rotatory nystagmus of the patient in the upright position.

So in 8 cases the horizontal canal was damaged during the operation, but in 6 of these the damage proved to be reparable. To pronounce with certainty on the nature of the damage is, of course, difficult except in the case in which the membranous horizontal canal was removed during the operation, but most likely the pathologic alteration was purely mechanical or was caused by hemorrhage. It was hardly the result of infection.

In 2 cases the nystagmus released from the side operated on was directed obliquely downward, probably because of the demonstrated spontaneous nystagmus directed to the side not operated on.

In 5 cases the lateral nystagmus released from the side of operation was, peculiarly enough, combined with a rotary nystagmus to the



opposite side. In one of these a similar combination was found to be released from the side not operated on.

Finally, there is reason to mention that in 5 cases the duration of the nystagmus released from the side not operated on was under half of that of the nystagmus released from the side of operation. In one case the difference was particularly great—four and forty-three seconds, respectively—and in another no nystagmus whatever was released from the side not operated on. This was no doubt due to a tendency of nystagmus toward the side that was operated on.

*Rotation with the Patient's Head Bent Forward or Backward—*

Rotation with the head of the patient bent forward or backward brings about rotary nystagmus, which is released from the superior and posterior canals on the side to which the nystagmus is directed. Prior to the operation 49 patients were tested for rotary nystagmus. In 2 no rotary nystagmus could be brought about in one of the positions (in one case no rotary nystagmus to one side, and in the other, neither to one side nor to the other), probably on account of a lesion in the vestibular apparatus. In one of these cases also the postrotatory lateral and vertical nystagmus presented abnormal conditions.

After the operation the rotary nystagmus was absent in several patients, mainly that released from the side of operation. If we leave out of account the patients in whom there was spontaneous nystagmus on examination, the rotary nystagmus released from the side operated on was absent in 12 patients, either with the head bent forward or backward, or in both positions. In all these patients the conditions were normal before the operation. The rotary nystagmus released from the side not operated on was absent in 1 patient in both positions, and in 2 patients both that from the side of operation and that from the opposite side were absent in one or in both positions. In these 3 patients with disturbances on the side not operated on or on both the side of operation and the side not operated on the conditions were normal on subsequent examinations.

Of the 12 patients with disturbances exclusively on the side of operation subsequent tests showed pathologic conditions persisting in 1 patient only, whereas the reaction was normal in the remaining 11 patients.

The observations described suggest that there were disturbances of the function of either the superior or the posterior canal or both canals in these patients. In most of them these disturbances were, however, transitory only.

*Rotation with the Head Bent to the Right or to the Left—*Rotation with the head bent to the right or to the left brings about vertical nystagmus. The downward directed vertical nystagmus is released

from the two superior canals and the upward directed vertical nystagmus from the two posterior canals

Forty-nine patients were tested for vertical nystagmus prior to the operation. In 2 patients the upward directed vertical nystagmus could not be elicited with the head either on the right or on the left shoulder, presumably on account of vestibular disturbances. In one of these patients also the postrotatory lateral and rotary nystagmus presented abnormal conditions. After the operation the upward directed vertical nystagmus was absent in 4 patients without spontaneous nystagmus in the position concerned—in 2 patients in one position only and in the other 2 in both positions. In 1 of these 4 patients the same pathologic conditions were present also before the operation. Finally in some patients (in part with spontaneous nystagmus) the released nystagmus had an oblique direction.

A total of 15 patients presented abnormal conditions of postrotatory nystagmus released from the vertical canals. Slight or more pro-

TABLE 7—*Abnormalities of Postrotatory Nystagmus*

Prior to Operation	
Type of Nystagmus	Patients Presenting Abnormal Reactions
Lateral (77 patients)	7 *
Rotary (49 patients)	2 *
Vertical (49 patients)	2 *
After Operation (78 Patients)	
Lateral	{ 12 (slight changes) 8 (pronounced changes)
Rotary	
Vertical	

\* In 1 patient there were abnormalities of all three directional types of nystagmus

nounced changes of the postrotatory lateral nystagmus were demonstrated in 7 of these patients.

Table 7 illustrates the results of the rotation tests, part of which were made before and part after the operation.

#### NYSTAGMUS PRODUCED BY THE CALORIC TEST

**Before Operation** The caloric test was made prior to the operation on all patients except 2. One hundred cubic centimeters of water, at 10 to 15 C, was applied for the test. In 27 cases the test was made only with the patient in the upright position and with the head bent forward, while in the remaining 50 cases it was made also with the head bent to the sides and backward.

Five patients reacted abnormally before the operation. In 3 the released nystagmus ceased when the head was bent forward, in a fourth a purely rotary nystagmus to the opposite side was seen with the head bent forward and in the fifth the nystagmus became vertical

downward in the forward bent position, and in this case the nystagmus ceased when the head was bent backward

**After Operation** All the patients were tested except 3. On 43 patients the test was made first one to two weeks after the operation, on 15 patients two to three weeks after, while on the remaining patients it was not made till between three weeks and six and one-half months after the operation. The test, which was generally made with insufflation of air, was carried out several times, and the reactions were observed with the patient's head in the different positions.

The test revealed abnormal conditions in 48 of 76 patients. Four of the 48 patients reacted abnormally also before the operation. In 30 of these 48 patients the reactions were normal except for a lack of change of the lateral nystagmus in the forward bent position of the head. One of these patients was the one mentioned whose membranous horizontal canal had been removed during the operation. Subsequent performances of the test gave change of the lateral nystagmus at forward bending in no more than 3 of the patients. In another patient the test when made the first time, seventeen days after the operation, showed change at forward bending of the head, but not when made the second and the third time, five and eleven months, respectively, after the first.

Twelve of the 48 patients presented other abnormal reactions. In 8 the nystagmus could be released only in certain positions, in 2 the nystagmus was only lateral or rotary, and in 2 paradoxical reactions were noted. Eleven of these 12 patients had failing change in the forward bent position as well. In 1 patient only, with paradoxical reactions, did the nystagmus change toward the cooled-down side when the head was bent forward.

In 6 of these 12 patients the reactions had been normal previously except for a lack of change at forward bending. In 2 there was no caloric reaction whatever at one time, but later there were normal reactions except for the lack of change when the head was bent forward.

In 10 of the 12 patients the caloric reactions became normal later, yet still with lack of change at forward bending.

Finally, in 6 of the 48 patients the caloric reaction could not be released. Five of these had spontaneous nystagmus, and the stimulus applied, generally insufflation of air, may not have been strong enough. Subsequent tests gave normal reactions except for lack of change when the head was bent forward.

The points of time at which normal reactions, except for lack of change, were demonstrated in the latter two groups, comprising 18 patients, ranged from five weeks to fifteen months after the operation.

The results of the caloric test have been recorded in table 8.

## COMMENT

The results of the different tests have been recorded in table 9

The question of particular interest to be elucidated is whether the reversal or the varying or the absence of the fistula sign (despite the unquestionable presence of the fistula on the vestibule or the adjacent part of the horizontal canal) and the abnormal caloric reaction are due to loss of function of the horizontal canal

TABLE 8—*Abnormalities Observed at Caloric Tests Made After the Operation (76 Patients Tested)*

Type of Abnormality	Patients Presenting Given Abnormality
Falling change at forward bending	30
Other abnormal reactions	12
Loss of caloric reaction	6
Total	48

TABLE 9—*Combinations of Abnormalities of Function Observed in the Different Tests*

	Failing Postrotatory Reaction from Horizontal Canal (8 Patients)	Reduced Postrotatory Reaction from Horizontal Canal (12 Patients)	Abnormal Caloric Reaction (48 Patients)	Absence of Fistula Sign (13 Patients)	Reverse or Varying Fistula Sign (12 Patients)
Failing postrotatory reaction from horizontal canal (8 patients)			6	2	3
Reduced postrotatory reaction from horizontal canal (12 patients)			9	2	5
Abnormal caloric reaction (48 patients)	6	9		12	6
Absence of fistula sign (13 patients)	2	2	12		
Reverse or varying fistula sign (12 patients)	3	5	6		

The absence of postrotatory reaction from the horizontal canal constitutes the basis for an investigation of this question

It appears from table 9 that in 11 of 13 cases with absence of the fistula sign the horizontal canal reacted on the rotation stimulus, though the reaction was impaired in 2 cases. Thus, absence of the fistula sign was not necessarily due to loss of function of the horizontal canal. It may have been due to the fact that the pressure could not act on the membranous labyrinth through the plastic flap or to the fact that the horizontal canal was slightly damaged, since in 12 of the 13 patients with absence of the fistula sign the caloric test gave no change of the lateral nystagmus when the head was bent forward.

The conditions are similar where the reverse sign or the alternately regular and reverse fistula sign are concerned. In 9 of 12 cases the

horizontal canal reacted on the rotation stimulus, though somewhat weakly in 5 cases, and further in 1 case the caloric test gave no change of the lateral nystagmus in the forward bent position. The fact that the fistula is not situated exclusively on the horizontal canal but rather over the area of contact between its ampullar end and the vestibule most likely accounts for the reverse or mixed reverse and regular fistula sign in some cases. Similar conditions have been described by Nylén<sup>3</sup> for the fistulous labyrinthitis.

The fistula sign could be elicited, presumably released by pressure on the sensory epithelium, in 6 of 8 cases with absence of postrotatory reaction from the horizontal canal.

As to the abnormal caloric reaction, notably the failing change of the lateral nystagmus in the forward bent position of the head, it appears that the horizontal canal responded to rotation in 42 of 48 such cases.

This observation agrees with the results of Lund's<sup>4</sup> investigations to the effect that one cannot conclude from the lack of change at forward bending of the head that the horizontal canal has lost its function. The lack of change, seen in such a large number of cases, viz., 62 per cent, may be due to a slight damage of the horizontal canal not involving total loss of the function of the canal. This accords with the fact that slight disturbances of the postrotatory lateral nystagmus were observed in 9 of the 42 cases.

In 2 cases the caloric test when made the first time after the operation gave downward directed vertical nystagmus when the head was bent forward, whereas when it was made subsequently there was a change of the lateral nystagmus. The fistula sign was regular in both these cases, and the horizontal canal responded to rotation. I am here in agreement with Lund,<sup>4</sup> who found that one cannot draw from the development of vertical nystagmus the general conclusion that the horizontal canal has lost its function.

In 2 cases with absence of postrotatory reaction of the horizontal canal the caloric reaction was normal with change at forward bending. This goes to show that the occurrence of the change is no definite proof that the normal function of the horizontal canal is present.

As mentioned before, 15 patients presented abnormal conditions of postrotatory nystagmus released from the vertical canals, and in 7 of them slight or pronounced changes of the postrotatory lateral nystagmus were demonstrated. Furthermore, the caloric reaction was now abnormal in 10 of these 15 patients. Slight or severe damage of the horizontal

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3 Nylén. A Clinical Study of the Labyrinthine Fistula Symptoms and Pseudofistula Symptoms in Otitis, *Acta oto-laryng*, 1923, supp 3, pp 1-511.

4 Lund, R. La fonction vestibulaire dans la labyrinthite fistuleuse, *Rev de laryng* 54 285, 1933.

canal was demonstrated by rotation tests and/or caloric tests in 12 of these 15 patients

The results of the investigations show that in a great number of the patients (45 of 78) the function of the horizontal canal was reduced—in a small number of these (8) even completely lost—after operation for otosclerosis. The function returned, however, in several cases

The vertical canal was affected to a far smaller extent (only in 15 of 78 patients). The damage was rarely of a permanent nature

In short, the most pronounced disturbances were demonstrated at the site of operation, the ampulla of the horizontal canal. The disturbances decreased in the remaining part of the vestibular apparatus, without reaching the cochlear apparatus, except in 2 cases, which are the only ones in which the hearing was impaired after the operation. This shows the great importance of antibiotics for the fenestration operation

#### SUMMARY

The vestibular function has been tested in 79 patients before and after operation for otosclerosis

Twenty-seven per cent of the patients had been suffering from vertigo before the operation. This symptom was present after the operation in 64 of the 79 patients

Spontaneous nystagmus was demonstrated in the majority of the patients after the operation, varying in both duration and direction

The fistula sign was originally present in 57 patients, but later disappeared in 11. If the fistula is still open six months after the operation, it is likely to remain so. The fistula sign was generally regular. The direction may differ with the different methods of testing. The vascular fistula sign was a frequent occurrence, also after the area of operation had healed. This sign is, in other words, not released by changes of volume of the granulation tissue in the fistula

In rotation and caloric tests, some patients presented signs of a lesion of the vestibular apparatus before the operation. After the operation such signs were frequent, notably signs of damage to the horizontal canal and, less frequently, to the two vertical canals

The fistula sign may be absent despite functioning of the horizontal canal, and, reversely, the fistula sign may be elicited despite loss of function of the horizontal canal

## IV BIOCHEMICAL CONDITIONS IN PATIENTS WITH OTOSCLEROSIS

NIELS RISKAER, M D

SINCE 1912, when Voss<sup>1</sup> suggested the possibility of a relationship between otosclerosis and disturbances of the function of the parathyroid gland, various investigations have been published with the object of demonstrating metabolic disturbances of different kinds in association with this disease

Attention has been focused particularly on the calcium metabolism. However, there have been reports also on investigations of the inorganic phosphate, cholesterol and protein contents of the serum, as well as a few on the serum potassium, magnesium, chlorine and lactic acid, the alkali reserve, the sugar metabolism and the basal metabolism. The latter investigations comprise only fairly small materials, and no great importance seems to have been attached to them.

The results achieved by the various investigators are not comparable. A brief survey, therefore, will be given here of the most important reports, comprising studies concerning calcium, inorganic phosphates, cholesterol and protein.

### SURVEY OF THE LITERATURE

*Calcium*—Leicher<sup>2</sup> (1922 and 1923) analyzed serums from 40 patients with otosclerosis and claimed to have found subnormal calcium values in 75 per cent and, in the remaining 25 per cent, an abnormal instability of the calcium metabolism. Thus, on administering 5 to 6 Gm of primary sodium phosphate daily for from eight to fourteen days he observed a small but distinct fall in the calcium level, whereas such a fall was not demonstrable in normal persons. Results in conformity with this observation have since been published by Behrendt and Berberich,<sup>3</sup> Stern<sup>4</sup> and Altman and Kopetzky.<sup>5</sup>

Lindeman,<sup>6</sup> on the other hand, stated in 1928 that, by analyzing serums from 25 patients with otosclerosis, he found a normal calcium level in all except 2, in whose serums it was 7.1 and 7.7 mg per hundred cubic centimeters, respectively, without the patients otherwise present-

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1 Voss, O. Verhandl. d. deutsch. otol. Gesellsch., 1912, p. 193.

2 Leicher, H. Ztschr. f. Hals-, Nasen- u. Ohrenh. 4, 74, 1922-1923.

3 Behrendt, H., and Berberich, J. Ztschr. f. d. ges. exper. Med. 78, 31, 1931.

4 Stern, cited by Behrendt and Berberich.<sup>3</sup>

5 Altman and Kopetzky, cited by Fowler.<sup>7</sup>

6 Lindeman, C. F. Norsk mag. f. lægevidensk. 89, 223, 1928.

ing any particular signs or symptoms Fowler<sup>7</sup> and Nager<sup>8</sup> arrived at similar results a few years later by analyses of serums from 58 and 30 patients with otosclerosis, respectively. In no case did they find values which could be said for certain to lie outside the normal range of variation.

Breitmann,<sup>9</sup> by examination of a fairly large number of patients, found the serum calcium level normal in the majority, but he encountered some whose serum gave either abnormally high or abnormally low values.

Finally, Seiferth<sup>10</sup> stated that the serum calcium level is normal in some patients with otosclerosis, but in most, raised. (Among 22 patients he found hypercalcemia [calcium higher than 12 mg per hundred cubic centimeters] in 7, slightly raised levels [11 to 12 mg] in 7, normal levels [10 to 11 mg] in 7 and a slightly lowered calcium level in 1. Seiferth claimed at the same time to have found increased excretion of calcium in the urine in all cases except 2 [normal value set at 180 to 200 mg for twenty-four hour urine].)

These findings were, in Seiferth's opinion, borne out through experiments with dihydrotachysterol (A T 10<sup>®</sup>), which ostensibly gave favorable results in a number of cases. This observation has been supported by various other investigators, including Kobrak,<sup>11</sup> who, however, often combined the treatment with injections of calcium.

*Inorganic Phosphate*—Behrendt and Berberich<sup>3</sup> made analyses of serums from a fairly large series of patients of Voss's Clinic and found normal values for inorganic phosphate in all cases. Similarly, Fowler<sup>7</sup> stated that the phosphate contents of the serum samples examined by him from 58 patients were normal.

In contrast with these writers, Seiferth<sup>10</sup> claimed to have found reduced concentration of phosphate in the serums of the majority of the 19 patients examined by him. In 7 patients Seiferth found the level to be under 3 mg per hundred cubic centimeters, which Behrendt and Berberich and Fowler regarded as indicating pronounced hypophosphatemia, in 8 patients Seiferth found between 3 and 4 mg per hundred cubic centimeters, which is regarded as subnormal, in 2 patients the levels were slightly raised (4.6 to 4.8 mg), and in 2 patients they were quite normal (3.9 to 4.2 mg). Summarizing, Seiferth stated that the majority of patients with otosclerosis have increased concentration

<sup>7</sup> Fowler, E. P. Calcium, Phosphorous and Cholesterol in Otosclerosis, *Arch Otolaryng* **13** 77 (Jan) 1931.

<sup>8</sup> Nager, F. R. *Ztschr f Hals-, Nasen- u Ohrenh* **34** 717, 1933.

<sup>9</sup> Breitmann, M. (a) *Arch f Ohren-, Nasen- u Kehlkopfh* **135** 289, 1933. (b) **136** 117, 1933.

<sup>10</sup> Seiferth, L. B. *Arch f Ohren-, Nasen- u Kehlkopfh* **143** 429, 1937.

<sup>11</sup> Kobrak, F. *Pract oto-rhino-laryng* **1** 186, 1938.



of calcium and at the same time decreased concentration of phosphate in their blood serum, so that the formula corresponds to that seen in Recklinghausen's osteitis fibrosa

*Cholesterol*—Behrendt and Berberich,<sup>3</sup> through comprehensive investigations, arrived at the result that a decreased cholesterol content is a characteristic and constant finding in the blood serum of patients with otosclerosis. Breitmann,<sup>9</sup> on the other hand, stated that an increased amount is nearly always found, at least in elderly patients. Fowler found normal, or nearly normal, not definitely pathologic values in his series of cases.

*Proteins*—Only one paper has been found dealing with the proteins in the serum of patients with otosclerosis, namely, that published by Stern,<sup>4</sup> who claimed to have found a relative increase of the globulin fraction.

#### MATERIAL OF PRESENT INVESTIGATIONS<sup>12</sup>

The series of patients studied, from the ear department of Sundby Hospital, comprised 51 patients among those operated on for otosclerosis in 1947, 34 were women between the ages of 24 and 65, and 17, men between the ages of 26 and 67.

The blood serum analyses comprised calcium, inorganic phosphate, phosphatase, total cholesterol, albumin and globulin.

All samples were taken from fasting patients.

#### METHODS OF ANALYSIS AND NORMAL VALUES

The methods of analysis used and normal values are outlined.

*Calcium*—Tisdall's<sup>13</sup> modification of the Kramer-Tisdall method.

Maximal range of variation  $\pm 0.2$  mg per hundred cubic centimeters.

Normal value (90) 9.5 to 11 (11.5) mg per hundred cubic centimeters.

*Total Cholesterol*—Brun's method as modified by Brøchner-Mortensen and Møller.<sup>14</sup>

Maximal range of variation  $\pm 8$  mg per hundred cubic centimeters.

Normal value. In adults, most often 150 to 300 mg per hundred cubic centimeters, in a few cases, slightly higher.

*Phosphatase*—The Buchs's method.<sup>15</sup>

Maximal range of variation 0.5 unit.

Normal value in adults, 2 to 8 units.

*Inorganic Phosphate*—The Gutmans' method,<sup>16</sup> modified.

Maximal range of variation  $\pm 0.4$  mg per hundred cubic centimeters.

Normal value, adults, 2 to 5 mg per hundred cubic centimeters.

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12 These investigations were carried out in the Panel Doctors Laboratory with financial support from, and under the direction of, the municipal hospitals in Copenhagen.

13 Tisdall, F. F. *J Biol Chem* **56** 439, 1923.

14 Brøchner-Mortensen, K., and Møller, E. *Acta med Scandinav* **103** 259 1940.

15 Buch, I., and Buch, H. *Acta med Scandinav* **101** 211, 1939.

16 Gutman, E. B., and Gutman, A. B. *J Biol Chem* **136** 201, 1940.

*Protein*—The method of Henriques and Klausen<sup>17</sup>

Maximal range of variation total protein, 0.2 mg per hundred cubic centimeters, globulin, 0.3 mg per hundred cubic centimeters

Normal value total protein, 5.6 to 8.2 mg per hundred cubic centimeters, globulin, 1.6 to 3.2 mg per hundred cubic centimeters, albumin, 3.5 to 5.5 mg per hundred cubic centimeters

## RESULTS

To give the clearest possible survey of the results, each series of analyses will be dealt with separately

Each series of analyses was carried out on blood serum samples from all 51 patients

*Calcium* (normal value, 9.0 to 11.5 mg per hundred cubic centimeters) —The first analyses showed normal levels in 48 patients. In 3 patients the levels varied a little from the normal range, being 8.1, 12.0 and 11.9 mg, respectively. However, control analyses carried out from three weeks to three months later revealed normal levels also in these 3 patients: 10.0, 10.3, and 9.9 mg, respectively

*Inorganic Phosphate* (normal value, 2 to 5 mg, per hundred cubic centimeters) —The first analyses showed normal values in 44 cases. Abnormal values were found in the remaining 7 (in 5 of these varying only slightly from the normal range), being 7.0, 1.7, 5.2, 5.2, 1.8, 5.3 and 6.1 mg, respectively. In the first, third and fifth cases of abnormal concentration repeated analyses were made from ten days to three months later, by which normal values were demonstrated: 2.4, 4.4 and 3.3 mg, respectively

*Phosphatase* (normal values for adults 18 to 55 years of age, 2 to 7 units, for patients more than 55 years of age, 3 to 8 units) —The first analyses showed normal levels in 44 patients. In 7 the result deviated from the normal range of variation—in the majority, only slightly, however. For 6 of these patients, 18 to 55 years of age, the values were 7.5, 1.0, 7.4, 1.7, 10.0, and 8.5 units, for 1 patient, aged 56, 9.4 units

Control analyses were made for nos. 2, 5 and 6. The levels were now normal in all 3: 2.0, 4.6 and 6.0 units, respectively

*Total Cholesterol* (normal value 150 to 300 mg per hundred cubic centimeters, possibly slightly higher) —The first analyses showed normal values in 47 cases. In the remaining 4 there were deviations from the normal, in 3 of these it was quite small, the values being 342, 315, 147 and 98 mg

Control analyses made in 2 of these cases (nos. 3 and 4) about two months later revealed normal values: 258 and 301 mg, respectively

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<sup>17</sup> Henriques, V., and Klausen, U. *Biochem. Ztschr.* **254**: 414, 1932

*Protein*—The normal values per hundred cubic centimeters are

	Total Protein		Globulin		Albumin
Men	63.81 mg	}		}	41.55 mg
Women	56.82 mg		16.32 mg		35.54 mg

On the first analyses the total protein content was within the normal range of variation in 50 cases. One patient only (a woman aged 37) presented a slight deviation, the protein level of her serum being 84 mg.

The globulin content was normal in 43 cases, while minor deviations were noted in the remaining 8. In most of the latter the values were below the lower normal limit: 13, 12, 33, 13, 53, 14, 12 and 34 mg, respectively. The values for total protein were normal in all these cases.

The albumin values were normal in 39 cases. In 12 patients minor deviations were presented: 61, 58, 59, 56, 57 mg in men, and 22, 63, 58, 56, 59 and 57 mg, respectively, in women. In no more than 4 patients did both albumin and globulin levels deviate from the normal—in all, only slightly. The total serum protein was, as stated, slightly increased in 1 patient only.

#### COMMENT

In general, it may be said that in the great majority of the cases of otosclerosis normal values were found on the first analysis for all the examined substances. In the cases presenting deviations, the latter were most often very small, and for none of the substances was any tendency in the direction of a rise or a fall of the serum concentration noted. Where control analyses could be made after demonstration of abnormal values for one of the substances, such values were no longer present, but normal levels were found in all cases.

The final result is, then, that definitely abnormal values could not be demonstrated for any of these substances in the cases of otosclerosis examined.

If this result is compared with those of previous investigations, fair agreement is seen with Lindeman's,<sup>6</sup> Fowler's<sup>7</sup> and Nager's<sup>8</sup> findings, whereas it is not in agreement with the results achieved by Voss's collaborators (Leicher,<sup>2</sup> Behrendt and Berberich<sup>3</sup> and Stern<sup>4</sup>) and Serferth.<sup>10</sup> No definite explanation can be given for these differing observations, but it is worth noting that the latter writers put far stricter limits to the normal variations than has been thought possible here, a fact which, of course, cannot but influence the interpretation of the results of the analyses.

One cannot entirely leave out of account the possibility that at least the comparatively great differences may denote variations in the serum concentration in different phases, active and inactive, within the course of the otosclerosis. However, no certain observations have been made so far on which to base such a theory.

Fowler<sup>7</sup> attached great importance to the possibility of such variations at the early stages of otosclerosis for the early diagnosis, and consequently the prognosis and the prevention of the disease. He stated that in many cases it had proved possible to stop the progression of the otosclerotic changes by regulation of disturbances of metabolism and by prevention or termination of pregnancy. He held that hardness of hearing can be prevented if the process can be stopped before the development of the stapedial ankylosis.

In the report on the progress within the study of otosclerosis issued in 1946 by the American Otological Society<sup>18</sup> it was stated that Fowler had recommended systematic control of all persons descending from families in which otosclerosis occurs. Particular importance was attached to the control measures within the periods of life in which it is of the greatest significance that the development of otosclerosis be prevented or arrested. These periods are said to be the first six months of life, the ages between 10 and 20 (notably 11, 12, 13, 14 and 15) and, in women, also prior to and during pregnancy, puerperium, lactation and menopause, moreover, control is advisable in periods of particularly marked growth and periods of endocrine disturbances.

Fowler is of the opinion that, in addition to otologic examinations, the control should consist in measurements, at regular intervals, of the calcium, phosphorus, protein, folic acid and phosphatase contents of serum, as well as examination of the basal metabolic rate and absorption of minerals. During pregnancy and puerperium the intervals should not exceed two months.

#### SUMMARY

A brief survey is made of the reports published so far on investigations of the calcium, inorganic phosphate, cholesterol and protein fraction contents of the blood serum of patients with otosclerosis. The divergent results are pointed out.

Original investigations are reported, comprising measurements of the calcium, inorganic phosphate, phosphatase, total cholesterol, albumin and globulin in serum samples from 51 adult patients with otosclerosis. Definitely abnormal values of any of these substances could in no case be found.

It is mentioned that this result does not preclude the abnormal variations in active phases of the disease mentioned by Fowler, and his proposal that control examinations be made of descendants of patients with otosclerosis is cited.

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<sup>18</sup> A Report of Progress. Twenty Years Research in Otosclerosis, Progressive Deafness and Correlated Problems, 1926-1946, New York, American Otological Society, Inc. Central Bureau of Research, 1947.

## V CONDITIONS OF THE EXTERNAL AUDITORY MEATUS AND THE TYMPANIC MEMBRANE IN PATIENTS WITH OTOSCLEROSIS

SVEND SELSØ

IN EXAMINING patients with otosclerosis in the ear department of Sundby Hospital we have tried to find out whether conditions seen in the external auditory meatus and the tympanic membrane might be of importance in differentiating between otosclerosis and other forms of impaired hearing

The skin of the auditory meatus has been stated to be more disposed toward atrophy with reduced production of cerumen in patients who have otosclerosis than in normal persons and patients with other forms of deafness. Furthermore, it has been stated that the dimensions of the external canal are increased and the sensitivity of the skin reduced, that the tympanic membrane is thin with a reddish translucent promontorial wall, and that the mobility of the tympanic membrane is reduced as regards both the pars tensa and the membrana flaccida

I have examined 29 patients suffering from otosclerosis with regard to the signs and symptoms described in the foregoing paragraph. Twenty-nine persons with no disease of the ear have been used as controls

The ages of the patients with otosclerosis ranged from 26 to 67

The sensitivity was tested by means of a steel needle with a small piece of cotton wool, not rolled too hard, at the end. The tickling was done with a light hand. The patient, without having been instructed in advance, was asked about his (or her) sensation when the external auditory meatus and the tympanic membrane were touched

It appears from the table that a wide external auditory meatus was found a little more often among the patients with otosclerosis than among the controls. The same was the case with atrophy of the skin

Translucent redness seen through the tympanic membrane was found in no person within these two groups. Schwartz<sup>1</sup> was the first to show that atrophy with light-transmitting redness of the tympanic membrane was a characteristic finding in the patients with otosclerosis. This redness is not due primarily to hyperemia of the

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1 Schwartz H. Handbuch der Ohrenheilkunde, Leipzig, F. C. W. Vogel, 1892, p. 915

mucosa of the middle ear but rather to transillumination of an abundance of blood in the new-formed bony tissue in the promontorial wall. According to Schmierer<sup>2</sup> the translucent red color is sometimes extended over the entire tympanic membrane and sometimes limited, as patches, to the upper and lower posterior quadrants. Both the diffuse and the circumscribed redness are manifestations of the same phenomenon, but, as far as I can see, the terms "transilluminating redness" and "Schwartz's sign" are both in use today. The latter denotes, then, the circumscribed red patch posteriorly on the tympanic membrane.

*Conditions of the External Auditory Meatus and the Tympanic Membrane in Patients with Otosclerosis*

		29 Patients with Oto sclerosis	29 Controls
External auditory meatus	{ Wide	7	0
	{ Normal	19	29
	{ Narrow	3	0
Skin	{ Atrophic	5	0
	{ Normal	24	29
Sensitivity	{ Tickling reflex	19	21
	{ No tickling reflex	10	8
	{ Cough reflex	0	0
	{ Pain reflex	0	0
Tympanic membrane	{ Translucent redness	0	0
	{ No transilluminating redness	29	29

The cerumen production was found to be the same in patients with otosclerosis and in controls.

Wojniak<sup>3</sup> examined 100 patients who had otosclerosis and 100 controls. Of the latter, 70 had normal hearing, while 30 had other forms of deafness than otosclerosis, chiefly nerve deafness. Wojniak's results agree with those recorded by us in Sundby Hospital, only he stated that the lumen of the external auditory meatus generally is larger in patients with otosclerosis than in persons with normal hearing, whereas it is about the same size as that observed in patients suffering from other forms of impaired hearing.

Furthermore, Wojniak found Schwartz's sign to be present in 21 per cent of the patients with otosclerosis, but present also in 10 per cent of the patients with other forms of deafness and in 42 per cent of the normal controls.

Finally, Wojniak observed absence of mobility of the handle of the malleus in 47 per cent of the patients with otosclerosis, 23.3

<sup>2</sup> Schmierer, I. *Monatschr f Ohrenh* 58:965, 1924.

<sup>3</sup> Wojniak, F. *The External Ear and Drum Membrane in Otosclerosis*, *Arch Otolaryng* 44:249 (Aug) 1946.

per cent of the patients with other forms of deafness and 14.2 per cent of the normal controls. This examination was not undertaken in Sundby Hospital.

My associates and I have made investigations of sensitivity on patients with otosclerosis after operation and found the conditions to be almost the same as before operation.

The conclusion to be drawn from the results of the investigation must be that the external auditory meatus and the tympanic membrane present no characteristics that may contribute to differentiate otosclerosis from other forms of deafness.

# ACTINOMYCOSIS INVOLVING ETHMOID AND MAXILLARY SINUSES

Report of a Case

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AND

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WHILE actinomycosis is an unusual disease, it can hardly be considered rare. Actinomycosis of the jaws is not uncommon. Thus Axhausen<sup>1</sup> claimed that he saw 30 cases in an average year. In all, however, the disease is rare enough that it is not often thought of as a diagnostic possibility. This is particularly true in the field of otolaryngology, where the reports of invasion of the paranasal sinuses are exceptional. Why this situation should exist when the disease is commonest in the jaws and the cervicofacial region is a matter for conjecture and further study. Reports of actinomycetic infections involving the maxillary sinus have been rare. Voss<sup>2</sup> (1939) reported 1 case, as did Hersh<sup>3</sup> in 1945.

Matheis<sup>4</sup> stated that 60 per cent of all cases of actinomycosis involve the head and neck, the typical history beginning with a dental extraction. Of Dobson and Cutting's<sup>5</sup> 11 cases of cervicofacial actinomycosis, there had been dental extractions in 9. In 6 of these instances there had been extractions before the infection became evident, and in 3 cases extrac-

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Published with the permission of the Chief Medical Director, Department of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed and the conclusions drawn by the authors.

1 Axhausen, G. Early Clinical Picture of Jaw Actinomycosis, *Deutsche med Wchnschr* **62** 1449-1451 (Sept 4) 1936, *Das Fruhbild der Kieferaktinomykose*, *Arch f klin Chir* **183** 21-23, 1935.

2 Voss, H G W. Actinomycosis, *J Am Dent A* **26** 260-263 (Feb) 1939.

3 Hersh, J H. Primary Infection of Maxillary Sinus by *Actinomyces Necrophorus*, *Arch Otolaryng* **41** 204-207 (March) 1945.

4 Matheis, F S. Actinomycosis of Jaws and Diseases with Similar Symptoms, *Internat J Orthodontia* **23** 1032-1044 (Oct) 1937.

5 Dobson, L, and Cutting, W C. Penicillin and Sulfonamides in the Therapy of Actinomycosis. Report of Sixteen Additional Cases and in Vitro Tests of Susceptibility of *Actinomyces* to Penicillin and Sulfadiazine, *J A M A* **128** 856-863 (July 21) 1945.



tions were accomplished after the infection started Axhausen<sup>1</sup> stated that these infections are produced by pyogenic organisms The pyogenic infection is primary, forming a submucous or perimandibular abscess which drains intraorally or externally or establishes osteomyelitis This development prepares the ground for the actinomycetic infection In the beginning, the actinomycosis is a secondary infection, later, the actinomycosis is the main infection, and the pyogenic infection is secondary

The causative agent of actinomycosis is *Actinomyces bovis*, a pathogenic, non-acid-fast, anaerobic, gram-positive fungus Bostrom in 1890 claimed that the saprophytic, aerobic, acid-fast organism found in grasses and cereals is identical with the one recovered from actinomycotic lesions He expressed the belief that the actinomycetes penetrated into the human tissues by means of awns, beards and straws, when these were introduced into the mouth by patients chewing on a blade of grass, barley or grain Emmons,<sup>6</sup> however, expressed the opinion that this was an unfortunate misconception due to Bostrom's mistaking a saprophyte for a pathogen Davis<sup>7</sup> stated that *A. bovis* is a facultative anaerobe, difficult to grow and grown only at body temperature According to Wolff and Israel,<sup>8</sup> *A. bovis* does not grow on grains and grasses at all but normally inhabits the digestive tract, particularly the mouth, where it remains as a saprophyte Given proper conditions, e g, lowered resistance and a portal of entry, the organism becomes pathogenic, with the production of a lesion

There has been much discussion regarding the mode of infection and the possible relationship between farm life and actinomycosis Sanford and Magath<sup>9</sup> reported 119 patients, of whom only 16 were farmers, who had actinomycosis in 1922 New and Figi<sup>10</sup> expressed the opinion that the disease is not contagious, as it is exceedingly difficult for one to produce it by injecting infected pus into animals They further stated that *A. bovis* has never been demonstrated outside the human body and, further, that it is an anaerobic organism and no spores have been demonstrated These organisms have been found in dental caries and tonsillar crypts of normal persons Sanford and

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6 Emmons, E W *Actinomyces and Actinomycosis*, Puerto Rico J Pub Health & Trop Med **11** 63-76 (Sept) 1935

7 Davis, M I J *Analysis of Forty-Six Cases of Actinomycosis with Special Reference to Its Etiology*, Am J Surg **52** 447-454 (June) 1941

8 Wolff, M, and Israel, J *Ueber Reincultur des Actinomyces und seine Uebertragbarkeit auf Thiere*, Virchows Arch f path Anat **126** 11-59, 1891

9 Sanford, A H, and Magath, T B *Etiology and Laboratory Diagnosis of Actinomycosis*, Minnesota Med **5** 71-80 (Feb) 1922

10 New, G B, and Figi, Γ A *Actinomycosis of Head and Neck*, Surg, Gynec & Obst **37** 617-625 (Nov) 1923

Magath<sup>9</sup> noted in almost all their 96 cases of cervicofacial actinomycosis a history of preceding dental or tonsillar disease

Matheis<sup>4</sup> stated that actinomycosis of the jaw is usually more dangerous than is that of the other bones. In the skeletal bones the infection is usually secondary to infection of the soft tissues, spread by contiguity or by way of the blood stream. In the jaw it is a primary infection spread through the root canals. The picture may be misleading, and hyperostosis of the mandible caused by actinomycetic infection of the periosteum may lead to a diagnosis of sarcoma. Matheis mentioned that, whereas in bacterial abscesses the infiltration decreases and disappears in time, in actinomycosis part of the infiltration will persist. The skin appears dark red or blue-red. There exists a normal or only slightly raised temperature. Spread of the disease into the antrum, orbit or brain may initiate meningitis or encephalitis and lead to death.

Ziskin, Shoham and Hanford<sup>11</sup> described the infection as beginning with a cellular reaction in the soft tissues, the consistency of the lesions varies from that of a soft, gelatinous granulation tissue to that of hard, fibrous tissue, resembling cartilage. One or more firm, reddish or purplish infiltrated nodules may be seen, this development is usually observed in acute cases or in later stages of the chronic cases. The swelling may include a hard nodule or a doughy mass, a widespread woodlike induration or a combination of all three. The lymph nodes are usually involved by centrifugal extension. The maximal swelling is usually noted at the angle of the mandible and extends into the submaxillary, parotidomasseteric regions and the side of the neck.

In cervicofacial cases, the suppurative process almost always develops outward to the skin, seldom pointing into the mouth. In the mandible the infection frequently invades the periosteum, then spreads to the bone, causing a true actinomycotic osteomyelitis. Sequestrums may form.

Actinomycosis has, as distinguishing characteristics, chronicity, multiple fistulas, exudate in which sulfur granules are found, deep-seated induration, sinus tracts with orifices which have a border of "pouting" granulation tissue, trismus (in cervicofacial cases), dysphagia and protrusion of the tongue. An actinomycetic infection should be suspected if, in spite of radical surgical excision of an abscess, a new abscess suddenly forms in the neighborhood of an old one.

The sulfur granules are small, yellow, gritty granules in the pus, microscopically these show chestnut-burr-like colonies, consisting of branched mycelial threads (hyphae), occasionally with very slightly

<sup>11</sup> Ziskin, D. E., Shoham, J., and Hanford, J. M. Actinomycosis. A Report of Twenty-Six Cases, *Am J Orthodontics (Oral Surg Sect)* 29: 193-201 (April) 1943.

clubbed ends Granules are not always present, however, for Berestnew<sup>12</sup> described an atypical form which did not produce the small, yellow, gritty granules

In the more recent references to therapy, the sulfonamide compounds and penicillin have been mentioned frequently as being effective The striking point, however, is that the patients usually have been treated by a number of agents Dobson, Holman and Cutting<sup>13</sup> in 1941 treated 3 patients with sulfanilamide, iodides and roentgen radiation Voss<sup>2</sup> treated 2 persons by drainage and roentgen irradiation Dobson and Cutting<sup>5</sup> (1945) used penicillin and sulfonamide compounds Thorson and Mueller<sup>14</sup> (1941) used thymol, potassium iodide and roentgen radiation

Ziskin, Shoham and Hanford<sup>11</sup> (1943) gave a summary of the therapy which they used (1) administration of drugs potassium iodide, sodium iodide, ethyl iodide, strong iodine solution U S P or a colloidal preparation of iodine, copper sulfate and sulfanilamide (iodine locally or in ointment form and potassium iodide by mouth in doses as high as 250 grains [16 Gm] or more per day), (2) irradiation roentgen rays, radium, ultraviolet light and alpine (violet) light (roentgen rays being the most effective), (3) and use of vaccine (autogenous), (4) supportive measures a diet with high vitamin content, and (5) surgical procedures complete excision in early stages or, if the lesion is extensive, incision, with the application of either 50 per cent or stick potassium hydroxide (a solution of acid, usually acetic acid, to be kept on hand to neutralize this caustic)

Hamilton and Kirkpatrick<sup>15</sup> (1945) reported that 2 patients had been treated successfully with penicillin (25,000 to 33,000 units every three hours), 1 patient received a total of 5,800,000 units, and the other, 5,200,000 units These authors stated that the different strains of *A. bovis* vary in their susceptibility to penicillin Of five strains examined by Garrod in 1944 and compared with the Oxford H strain of *Staphylococcus aureus* as a standard, two showed approximately the same degree of sensitivity as did the standard staphylococcus, a third strain was eight times as resistant, a fourth strain was four times as resistant, and a fifth strain grew sparsely and atypically in sixteen times the concentration of penicillin tolerated by the staphylococcus

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12 Berestnew, N Ueber Pseudoaktinomykose, *Ztschr f Hyg u Infektionskr* **29** 94-116, 1898

13 Dobson, L, Holman, E, and Cutting, W C Sulfanilamide in Therapy of Actinomycosis, *J A M A* **116** 272-275 (Jan 25) 1941

14 Thorson, J A, and Mueller, E F Probable Actinomycosis of Orbit, *J Iowa M Soc* **31** 70-72 (Feb) 1941

15 Hamilton, A J C, and Kirkpatrick, H J R Actinomycosis Successfully Treated with Penicillin Report of Two Cases, *Brit M J* **2** 728 (Nov 24) 1945

An outstanding pathologic characteristic of actinomycosis is the formation of fibrous tissue, the amount and maturity of which varies with the balance of such factors as the age and site of the lesion, the resistance of the patient's tissues and the virulence of the infecting organism. The amount of fibrous and granulation tissue and its age affect the vascularity of the lesion and the flow of blood through it, and consequently the permeation of the lesion by penicillin in the blood and

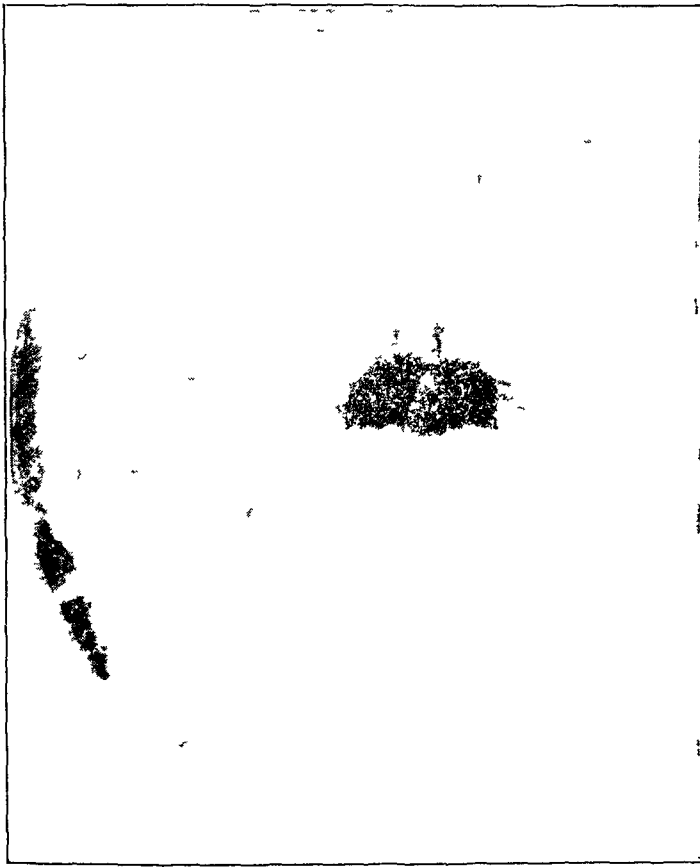


Fig 1—The roentgenogram shows clouding of the right maxillary sinus

the concentration of the drug attained in various parts of the lesion. Further, actinomycosis may show a considerable degree of latency, and relapses may occur a long time after apparent cure.

#### REPORT OF A CASE

W. D., a 58 year old steel finisher, admitted to the Veterans Administration Hospital at Hines, Ill., on Jan 2, 1947, gave a history of having had "flu" two weeks prior to admission and of having had a tooth extracted on Dec 30, 1946. The extraction had been followed on the next day by swelling and pain in the right side of his jaw and face and chills and fever. Physical examination on admission revealed that he was dyspneic and perspiring profusely, appeared seriously ill and had a temperature of 103 F. He had a diffuse, tender swelling of the right side

of his face and neck, including his eyelids and the lower portion of the scalp. He had an icteric coloration of the sclera and skin. His tongue and palate were swollen, and the view of the pharynx was obstructed. The right side of the neck was swollen, hard and tender. The diagnostic impression was of an acute extensive cellulitis of the right side of the face and neck.

The patient was treated initially with hot compresses and large doses of penicillin, and he was placed in an oxygen tent. He appeared to have an adequate airway. For about two months, the patient continued to have a septic temperature, which gradually subsided to normal.



Fig 2—The roentgenogram shows clouding of the right ethmoid sinus.

Six days after his admission, abscesses in the right cheek and suprapalpebral and infrapalpebral abscesses were opened and about 2 cups of purulent material was obtained. Twenty-six days after admission, an abscess under the scalp in the right parietofrontal area was incised and drained. At this time a roentgenogram of the paranasal sinuses showed distinctly decreased transparency in the region of the right maxilla (fig 1) and a defect in the infraorbital margin, changes suggesting destruction of bone. The right frontal and right ethmoid areas showed a decrease in transparency (fig 2).

Twenty-six days after admission, the patient was referred to the department of otolaryngology, and irrigation of the right maxillary sinus was performed. Profuse, purulent material was returned, and this patient was transferred to the otolaryngologic service.

Frequent irrigations of the right antrum and displacement treatment of the sinuses were instituted, with little change in the patient's condition. Hot compresses to the lids were applied continuously. Roentgenograms of the sinuses repeated two weeks after the first set showed essentially the same conditions as those revealed in the original films.

A roentgenogram taken five days after his admission showed a small sequestration in the right mandible.

On February 24, about eight weeks after admission, a right Caldwell-Luc operation and a transantral ethmoidectomy, with removal of osteomyelitic maxillary bone, were performed. A defect was found in the roof of the antrum.

After these procedures, the infection of the antrum and in the anterior facial region subsided, but the fistulas in the lids continued to drain copious amounts of pus, and marked edema of the lids and chemosis of the conjunctiva remained.



Fig 3—(A) The patient is shown before successful treatment. Chemosis of the eyelid and two orbital fistulas may be observed. (B) The patient is apparently completely cured. There is moderate discoloration of the skin around the orbit as the result of roentgen therapy.

The mouths of the draining sinuses showed heaped-up granulation tissue. Irrigation of the lower fistula produced drainage from the upper one, showing a connection between the two. Iodized oil U S P was instilled through the lower fistula, and a roentgenogram showed the sinus tract extending from the region of the anterior surface of the malar bone to a cavity in the lateral portion of the roof of the orbit and entering the sinus tract in the upper lid.

During the first twenty-four days the patient received 50,000 units of penicillin every three hours, intramuscularly, for a total of 9,600,000 units. At various other times during his treatment he received 7,300,000 more units of the usual type of penicillin and 3,300,000 units of penicillin in oil and white wax U S P. In all, he received 20,200,000 units of penicillin intramuscularly, as well as 7,000,000 units orally. For about four weeks he received sulfadiazine with the penicillin.

Cultures taken nine days after the onset of the infection revealed hemolytic and nonhemolytic *Staphylococcus albus*. Five weeks after the onset of the infection, hemolytic *Staph aureus* was recovered. Two months later an anaerobic culture showed nonhemolytic diphtheroids, and, about nine weeks after the infection began, another anaerobic culture revealed *A. bovis*.

Under the combined penicillin-sulfonamide therapy, to which oral administration of thymol, irrigations of the sinus tract with 10 per cent thymol and drainage were added, the inflammation gradually subsided about four months after its onset.

#### COMMENT

Retrospection indicates that the correct diagnosis might have been arrived at earlier than it was. The delay was due largely to the rarity of the disease in the antrum and the ethmoid sinus. Certainly in any chronic infection of the face, jaw or antrum which displays multiple abscesses and sinuses and which resists treatment repeated anaerobic cultures should be made in order that an accurate diagnosis may be established.

So many modes of treatment were tried in this case that it is difficult to decide which, if any, was effective. The first wave of improvement followed the surgical removal of the necrotic maxillary and ethmoid bones. However, shortly after this, improvement was at a virtual standstill, and it was at this plateau that the administration of thymol was instituted. It was given in rather small dosage, and there is left the question of the effectiveness of thymol in this infection. Its use had been preceded by roentgen therapy, which may have been having a long term beneficial effect.

In the light of this case and the previous experience of others, adequate treatment would seem to be in the form of a combined attack. Surgically, all abscesses should be opened and drained, and all necrotic bone should be removed. Medically, a combination of penicillin, sulfonamide drugs and thymol is desirable. Roentgen therapy should be used conjointly. The most important determining factor is early diagnosis.

#### SUMMARY

1 The record, with comment, is presented of a case of actinomycosis of the right maxillary and the right ethmoid sinus, with some cutaneous and orbital spread.

2 The problem of modern diagnosis and treatment of the condition is considered.

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## INTERPRETATION OF HEARING TESTS

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THE DETAILED reviews and discussions of evidence necessary to evaluate critically the reliability of the interpretations that have been made of hearing tests would take more time than is available today. This presentation will therefore be limited to general considerations of certain aspects of the topic.

### NONMEDICAL INTERPRETATIONS OF HEARING TESTS

To most members of the present audience, the title of this paper calls to mind medical problems. Before proceeding to the discussion of the medical aspects of the topic, however, I wish to remind you that hearing tests are interpreted and used in many ways other than diagnostic. For instance, since time immemorial every employer has noticed, consciously or subconsciously, the ability of applicants to hear and has interpreted these observations in terms of jobs. At the present time, the military services of our own and of other countries, without direct concern about the causes of poor hearing, have rules with respect to hearing acuity as part of their requirements for enlistment and for various types of duty assignments. Likewise, school administrators interpret hearing tests in terms of educational assignments to special classes or schools.

Modern telephonic and radio communication systems are all based on hearing tests interpreted in terms of electrical circuits and apparatus. To transmit electrically, without distortion, the entire range of frequencies of sound waves that man can perceive is an exceedingly difficult problem from the standpoint of apparatus, therefore acoustical physicists and engineers have devoted much time and energy to the study of how well the voice can be understood when its sounds are imperfectly transmitted and to the determination of what types of imperfections are permissible. Some of the results of these nonmedical interpretations of hearing tests are of great practical importance in the everyday life of tens of millions of persons, for instance, our telephone bills would

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be many times larger than they now are if for the understanding of speech it were necessary to have the receiver emit faithfully all the sounds that enter the distant mouth piece. Incidentally, some of the imperfections that have been found to be permissible are utilized deliberately in some forms of communication apparatus to reduce or to eliminate the transmission to the ear of extraneous sounds or noises which otherwise would interfere seriously with the understanding of the transmitted speech sounds.

Phonographs and talking movies are other examples of large scale applications of nonmedical interpretations of hearing tests. Architectural acoustics is also based on hearing tests. Unfortunately the builders of auditoriums often neglect the knowledge of specialists in this field.

The use of tests of hearing in the manufacture of hearing aids, as well as in their retail sale, is perhaps better known to the members of this audience than are the other examples of nonmedical interpretations of hearing tests that have been mentioned. The interpretations made of hearing tests in the designing and in the fitting of hearing aids, even by noncommercial persons, are basically different from those desired in medical diagnosis, and the topic, although of interest to many otologists, is mentioned now merely as another example of the numerous interpretations that are and can be made of tests of hearing.

#### MEDICAL INTERPRETATIONS OF HEARING TESTS

Medical men wish to interpret hearing tests in terms of physiology, of pathology and of therapy, not in terms of jobs, of apparatus or of school assignments. Unless they themselves are conducting investigations on deafness, otologists, when examining patients who are hard of hearing, wish mostly to determine why the deafness exists and to decide what can be done to alleviate the impairment present or to prevent the development of further impairment.

Every otologist is faced daily with the problem of how to interpret the tests he has made of a patient's ability to hear and also with the problem of whether additional tests would add information of value in the establishment of a diagnosis or in the decision as to what form of treatment, if any should be used. Most otologists feel a bit bewildered, to say the least, by the multiplicity of new hearing tests that have been devised and described during the past decade or so. Each test has been warmly advocated, often by several authors, for one purpose or another. Faced by this situation, the conscientious otologist often wonders whether, in fairness to his patients, he should not make provision for the administration of some or of all of these new, and usually elaborate and time-consuming, tests.

The problem is not a new one, even though the tests themselves may be. Over half a century ago, in 1896, Bezold<sup>1</sup> in one of his numerous papers about hearing tests wrote the following

In the course of recent years so many and in part time-robbing [*zeitraubende* is the word Bezold actually used] testing methods have been devised and carried out by various authors, that a purposeful, clear-headed, limitation of diagnostic procedures to the necessary and to the most certain and most rapid must be regarded today as indeed one of the most difficult tasks for otologists<sup>2</sup>

Many, but not all, of the tests of Bezold's generation have become of interest only to historians, but otologists still are faced with difficult choices between what may be termed "ideal" examinations of patients and what is practical

At least ten to twelve hours of time per patient would be needed to administer all the hearing tests now regarded by one or another investigator as of interest and value. The apparatus to make possible the administration of these tests would cost a minimum of several thousands of dollars. This figure does not include the cost of the special rooms needed for satisfactory use of the testing apparatus, nor does it include salaries of specially trained technicians to use the apparatus or payments to skilled electronics engineers to keep the various pieces of apparatus in proper operating condition.

The pure tone audiometer is the only apparatus for testing hearing, new since Bezold's time, that has been widely accepted in clinical otology. The diagnostic importance of a knowledge of air conduction thresholds for a series of tones, from low to high pitched, has long been recognized. For determining such thresholds the pure tone audiometer is a time saver, compared to other methods. Probably this is the reason that the audiometer, a by-product of hearing tests in nonmedical fields and itself regarded fairly recently as an elaborate test instrument, has been widely accepted and used by otologists. The other test procedures commonly used (the Weber, Schwabach and Rinne tests, performed with a 435 or a 512 double vibration steel fork, the watch tick, the whispered and the spoken voice) date well back into the nineteenth century.

By means of these older tests alone, made with suitable masking of the opposite ear when indicated, the hearing impairment which a patient has can quickly be classified as to type and usually as to subtype. Beyond this point, for purposes of diagnosis and therapy, the history and the physical examination yield the important clues. The cause of the impairment certainly cannot be determined by hearing tests considered without reference to the history and the physical

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<sup>1</sup> Bezold, F. Ueber den gegenwärtigen Stand der Hörprüfungen, Ztschr. f. Ohrenh. 29 1, 1896

<sup>2</sup> Translated by the author

examination. For instance a battery of hearing tests can distinguish between impaired hearing caused by otosclerosis and that caused by impacted cerumen, between impaired hearing due to advanced age and that in a 10 year old child afflicted with the Manasse type of hereditary progressive nerve deafness or between the possible causes of total deafness. The otologist therefore uses hearing tests primarily to supplement the data derived from history and physical examination and to confirm impressions already gained as to which part or parts of the organ of hearing are functioning poorly. He knows that by a series of elaborate, time-consuming tests several aspects of the patient's hearing disabilities, including thresholds, can be measured with more precision than by the tests he uses. He doubts, however, that this additional information will give reason to change the basic diagnosis that can be made from a carefully taken history plus a good physical examination and simple, quickly made tests. Furthermore, the otologist doubts that the elaborate tests will add information apt to change the decision as to what treatment, if any, is indicated.

The doubts of clinical otologists with respect to the preceding points are well founded. Only a few of the lesions that affect hearing can be seen and inspected during life, the correlations of these lesions with hearing losses are well established. Most of the lesions that cause impaired hearing can be studied only by histologic examination after death. By this method important correlations have been made with hearing losses known to have been present during life, but the number of cases that have been thus studied is too small to warrant conclusions as to the effect on hearing of small differences in lesions of the same general type. In other words, as yet only large differences in hearing can be correlated with differences in the lesions responsible for the impaired function.

The basic questions a clinician might well apply to each proposed hearing test are

- 1 What may I learn, that I do not already know, by making this additional test?

- 2 How good is the evidence that the interpretations made of data obtained by this test are correct?

- 3 If correct, what value do the interpretations made of the data from this test have in the care of patients?

The answers to these questions must always take into account the present state of knowledge not only of correlations between hearing losses and lesions but also of the physiology of the organ of hearing, which of course includes portions of the central nervous system as well as

the ear. The most important physiologic facts, all well known for years, are (1) that sound waves are transmitted to the organ of Corti according to the laws of that branch of physics known as acoustics, (2) that stimulation of the hair cells of the organ of Corti by sound waves causes the form of biologic activity known as nerve impulses to occur in fibers of the cochlear nerve and (3) that these nerve impulses are in some manner relayed via the chain of neurons of the auditory pathways to the auditory cortex of the cerebrum. Nothing is known of how the nerve impulses that reach the auditory cortex call forth perceptions of sound, meaningful or otherwise. Furthermore, the *modus operandi* of the hair cells of the organ of Corti is unknown, despite the numerous papers that have been published on the topic. The well documented fact, however, that the fibers of the cochlear nerve terminate about the hair cells of the organ of Corti does make the location of the transition from physical sound waves to biologic activity completely unquestioned. This fact is, indeed, the basis for the division of impaired hearing into the two broad groups of conductive deafness and nerve deafness. Anything which interferes with the normal transmission of sound waves to the organ of Corti gives rise to a conductive type of deafness, anything which decreases or prevents the normal reactions of the hair cells to stimulation by sound waves or which interferes with or prevents the normal reactions of the nerve fibers of the pathways from the organ of Corti to the cerebral cortex gives rise to what is termed nerve deafness. Both types of impairment may of course be present simultaneously and give rise to a so-called combined deafness.

Additional important facts about the organ of hearing, perhaps not so widely known as those previously mentioned but nevertheless so well established that they should always be kept in mind in choosing and in interpreting diagnostic tests, are (a) each organ of Corti sends nerve impulses not only to the opposite side of the brain, as formerly believed, but also to the same side, i. e., each ear has bilateral cortical representation, not merely contralateral<sup>3</sup>, (b) each part of the length of an organ of Corti sends nerve impulses to discrete parts of the cortex rather than diffusely to all parts of the auditory area, as was formerly believed<sup>3b, c</sup>, (c) high-pitched tones are mediated

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3 (a) Bunch, C. C. Auditory Acuity After Removal of the Entire Right Cerebral Hemisphere, *J. A. M. A.* **90** 2102 (June 30) 1928. (b) Woolsey, C. N., and Walzl, E. M. Topical Projection of Nerve Fibers from Local Regions of the Cochlea to the Cerebral Cortex of the Cat, *Bull. Johns Hopkins Hosp.* **71** 315 (Dec.) 1942. (c) Walzl, E. M. Representation of the Cochlea in the Cerebral Cortex. *Laryngoscope* **57** 778 (Dec.) 1947.

by the organ of Corti of the basal turn of the cochlea<sup>4</sup>, and (d) interference with the physical transmission of sound waves to the organ of Corti by conductive lesions often causes more impairment of hearing for high tones than for low tones<sup>5</sup>

The last statement is so at variance with classic concepts of the significance of impaired hearing for high tones that many otologists still do not accept and utilize the idea in their daily work. Proof of the statement, however, is so simple that every otologist can easily make the critical experiment himself. It is as follows: Determine the air conduction thresholds of an ear with good hearing and compare them with the thresholds of the same ear obtained when the external auditory canal is completely occluded by an obturator. The firmer the obturator, the greater is the impairment for high tones, certainly an obturator by its presence cannot cause a true nerve deafness.

Otologists and others who are interested in the careful selection and fitting of hearing aids use some rather time-consuming quantitative tests that are not of value in diagnostic work but are important in the securing of satisfactory utilization of an aid. As more and more otologists become actively interested in hearing rehabilitation, it is probable that diagnostic significance will become established for some of the functional differences that are revealed by tests of abilities of deaf persons to comprehend amplified speech. At the present time, however, histopathologic evidence does not exist to support any of the hypothetical interpretations that have been proposed as explanations of functional differences observed in the fitting of hearing aids on persons with otherwise similar degrees and types of deafness.

The statements made in this paper may give the impression that I am opposed to the use of any but the more simple hearing tests. Such an impression would be erroneous. My attitude, rather, may be summarized as follows:

The information obtained from the elaborate tests, or batteries of tests, is primarily of research interest, and until the significance of the data obtainable by these tests has been evaluated in terms of lesions that otherwise would be overlooked or in terms of therapy that otherwise would not seem indicated, clinical otologists should not be urged to use them or made to feel they are out-of-date if they do not. In other words, it is time for a clear distinction to be

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4 Habermann, J. Beitrag zur Lehre von der professionellen Schwerhörigkeit, *Arch f Ohrenh* 69 107, 1906. Crowe, S. J., Guild, S. R., and Polvogt, L. M. Observations on the Pathology of High-Tone Deafness, *Bull Johns Hopkins Hosp* 54 315 (May) 1934.

5 Crowe, S. J. and Guild, S. R. Impaired Hearing for High Tones, *Acta oto-laryng* 26 138 1938. Proetz, A. W. Hearing Acuity Varying with the Position of the Head, *Ann Otol, Rhin & Laryng* 57 241 (March) 1948.

made between tests for research purposes and those for clinical purposes. Nothing is gained clinically by the making of hearing tests that cannot be interpreted with reasonable certainty in terms of causative lesions. All too often a diagnosis, so-called, amounts to nothing but a statement of the kinds of hearing defects found by the tests made. Such a statement, no matter how elaborate the battery of tests used or how detailed the report of the data obtained, is merely a description, and not an interpretation, of hearing tests and has no medical usefulness whatsoever.

On the whole, it seems that the reluctance of most clinical otologists to spend time making refined, precise measurements by means of the elaborate methods devised for the testing of various aspects of the hearing function is justified by the paucity of interpretations of proved medical value. The situation constitutes a challenge to investigators.

#### ABSTRACT OF DISCUSSION

DR LAWRENCE R. BOIES, Minneapolis. This paper is valuable because it emphasizes a return to fundamentals. When I began the study of otology, the audiometer was coming into general use in institutions. As its use developed in the private practice of otology, some of us began to rely on it as an instrument for a more or less complete hearing test. We were not unlike the physician who examines the chest largely by roentgenology and neglects the art of careful physical study and to some extent history taking.

The audiometer has undergone marked improvements in the past twenty years, but it still remains, as Dr. Guild has inferred, an instrument for quickly and reliably measuring air conduction thresholds. Many otologists are hesitant to accept audiometric interpretation of bone conduction values and have more confidence in the time-honored tests with steel forks. Some of us who had been lulled into seeming security by the latest improvements in audiometric testing were stimulated to critical inquiry by the developments in regard to otosclerosis during the past ten years.

I think it may be safely said that among those who are now doing fenestration surgery the tests which would be discarded last in the critical evaluation of the patient would be those performed with tuning forks. Most surgeons who perform fenestrations apparently place the greatest reliance on the Rinne test performed with the 512, 1024 and 2048 forks. It is logical that the ability to understand speech should be the best criterion of one's practical ability to hear, and some tests have been developed and others are being developed and simplified which may become a desirable substitute for the tests with tuning forks. At the present time, however, it is my belief that we should continue to utilize the fundamental tests and teach them to our men in training.

Dr. Guild has had a background in certain fundamental phases of otologic research probably unsurpassed by anyone in the Americas and possibly elsewhere. This gives authority to his opinions, and for emphasis I would repeat his statement to the effect that "the information obtained from elaborate tests, or batteries of tests, is primarily of research interest, and until the significance of the data obtained by these tests has been evaluated in terms of lesions that otherwise would

be overlooked, or in terms of therapy that otherwise would not seem indicated, clinical otologists should not be urged to use them or made to feel that they are out-of-date if they do not"

DR JOHN R SIMPSON, Pittsburgh I wonder if some of you are not having the same experience that we are having in instructing young men in otology They do not seem to be interested in learning the use of tuning forks and too often refer the taking of an audiogram to a technician I wonder if they are not missing something by such practice I recall that some years ago Dr John B Rae, of New York, at a session of the Triological Society, gave a demonstration of the proper use of tuning forks It was one of the most instructive talks that I ever listened to in any society meeting

Those of us who have been brought up on tuning forks find their continued use helpful, and they serve as a check and supplement the information gained from the use of the audiometer

DR STACY R GUILD I wish to thank both discussers for their kind remarks I really expected a few brickbats I am sorry Dr Furstenberg could not be present to participate in the discussion Dr Simpson's point is most excellent, and I agree that stress should be placed on teaching the fundamentals of the testing of hearing As it is, all too often a secretary or a nurse or a technician puts on paper some lines which the physician responsible for the care of the patient accepts as a reliable hearing test

The paper today is the outgrowth of numerous conversations with visitors to the laboratory Most of the otologists, both from this country and from abroad, have wanted to talk about new hearing tests and what this, that or the other one means When Dr Woodward, the chairman, asked me to speak here, I thought more phases of the topic could be presented in fifteen minutes than has been possible The presentation today, therefore, must be regarded as chapter I or as a general consideration of the topic, to be followed later, perhaps, by detailed discussions and evidence on the various subtopics

## Abstracts from Current Literature

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### Ear

THE HEARING ACUITY, TINNITUS AND VERTIGO IN ESSENTIAL HYPERTENSION  
LEIGHTON F JOHNSON and BERNARD ZONDERMAN, *Laryngoscope* 58 374  
(May) 1948

Seventy-six consecutive cases of severe hypertensive vascular disease were studied to determine the relation to loss of hearing, tinnitus and vertigo. Complete examinations of the ears, nose and throat, including the taking of audiograms, were made. Tinnitus and vertigo were found to be very common, occurring in 30 and 46 per cent, respectively, and were frequently relieved by splanchnicectomy. There was little (10 per cent) subjective deafness, but a frequent dip of the audiometric curve at 2,896 and 4,096 double vibrations.

HITSCHLER, Philadelphia

OBSERVATIONS UPON THE LOUDNESS RECRUITMENT PHENOMENON, WITH  
ESPECIAL REFERENCE TO THE DIFFERENTIAL DIAGNOSIS OF DISORDERS OF THE  
INTERNAL EAR AND VIII NERVE. M R DIN, C S HALLPIKE AND J D  
HOOD, *Proc Roy Soc Med* 41 516 (Aug) 1948

From an investigation of the loudness recruitment phenomenon, the authors have derived conclusions that are proving to be major and brilliant contributions to otology. Using loudness balance tests, they studied 30 cases of unilateral deafness due to Meniere's disease and 20 cases of degeneration of the eighth nerve due to neurofibroma or other lesions of the cerebellopontile angle, as demonstrated at operation or autopsy.

Results indicated that the loudness recruitment phenomenon was present and complete in all 30 cases of Meniere's disease. Microscopic studies of the organs of Corti in cases of this disease generally revealed pathologic changes. Clinical deafness in many patients with Meniere's disease suggests that residual microscopic changes in Corti's organ exist but are obscured by the limitations of histologic technics. The nerve fibers and the cells of the spiral ganglions in these cases are normal.

Loudness recruitment was found to be absent in 14 of the 20 cases of degeneration of the eighth nerve. In the remaining 6 cases it was present, but incomplete. Microscopic studies of the organs of Corti in cases of degeneration of the eighth nerve generally showed normal structure. However, in these cases there was extensive pathologic change in the nerve fibers and in cells of the spiral ganglions.

Loudness recruitment was thus shown to be characteristically present in a disorder of the organ of Corti and to be characteristically absent in a disorder of the cochlear nerve fibers. These findings controvert present views on the neurologic mechanism of recruitment. The authors advance a new hypothesis based on their observations and other recent experimental work. They suggest that the loudness recruitment phenomenon may be very useful in distinguishing degeneration of the eighth nerve from disease of the peripheral end organ.

SATULOFF, Philadelphia



## Pharynx

TREATMENT OF TUBERCULOUS PHARYNGOLARYNGITIS WITH STREPTOMYCIN  
JOSE A. BERTELLI, *Rev argent de oto-rino-laringo* **17** 83 (March-April) 1948

Bertelli reports on a group of 16 patients with pulmonary tuberculosis in whom positive signs of involvement of the larynx or the pharynx appeared as complications of the pulmonary tract. The extent of involvement of the larynx varied from mild ulceration of the vocal cords to extensive lesions, not only of the cords and the arytenoid cartilages but also of the epiglottis. These patients received streptomycin therapy in large doses and for a long period. Some patients received as much as 125 Gm during the course of treatment. The cardinal symptoms of dysphagia, dysphonia and neuralgic pains were all affected favorably by the use of streptomycin. Nine patients who complained of dysphagia were cured, 8 of the 12 patients with dysphonia showed complete disappearance of this complaint, with definite improvement in 3 others. Laryngoscopic examination of these 12 patients showed complete cure in 6, almost complete cure in 2, pronounced improvement of the more extensive lesions in 3 and improvement in some of the discrete lesions in 5.

The untoward reactions are classified as of three types: (1) what Bertelli calls histamine reactions (headaches in 2 cases and nausea in 3), (2) neurologic disturbances (vertigo and nausea in 4 cases, hypoacusia in 2 cases, insomnia in 2 cases and ocular pain in 1 case), and (3) sensitization reaction (cutaneous eruptions in 1 case and fever in 1 case).

In his conclusions, Bertelli states: 1. Streptomycin is the most efficacious medication that we have at present for the treatment of laryngeal tuberculosis. 2. It is efficacious in treatment of all pathologic forms in this region. 3. The exudative forms are the most sensitive to treatment. 4. Dysphagia yields to treatment with the greatest promptitude. 5. A rapid alleviation of the painful symptoms benefits the general state of the patient, and a cure of these lesions eliminates an important obstacle to the better treatment of pulmonary lesions.

PERSKY, Philadelphia

## Nose

TURBINATE TREATMENT IN VASOMOTOR RHINITIS JOHN R. RICHARDSON, *Laryngoscope* **58** 834 (Aug.) 1948

The condition of vasomotor rhinitis is aggravated by the improper use of shrinking solutions. A careful history and study should be made and treatment carried out in conjunction with an allergist. When all forms of treatment apparently fail, and especially when no specific allergen is found, electrocoagulation and exfraction of the inferior turbinate body should be used. These methods give better results, in the author's hands, than injection with sclerosing fluids.

After local anesthetization, twin needles are inserted submucosally from the anterior to the posterior third of the inferior turbinate body. The current is applied, the needles are withdrawn, the current again applied, and so on, so that several areas of scar tissue are formed. Richardson treats the turbinate body first, four weeks later the patient returns to have the other side treated. The results are usually permanent.

Hitschler, Philadelphia

THE NEW TECHNIQUE FOR LOCAL ANESTHESIA IN SINUS SURGERY WILLIAM LAWRENCE GATEWOOD AND C AUGUSTUS DE VERE, *Laryngoscope* 58 848 (Aug) 1948

The authors discuss briefly the advantages of local anesthesia over that of general anesthesia, and treat separately each nerve involved in operations on the sinuses. Included are illustrations and explanations showing how and where the injection is made, the amount and strength of anesthetic solution and structures anesthetized by the nerve in question. The article is clear and concise and is good for reference before sinus surgery.

HITSCHLER, Philadelphia

THE ABUSED DIAGNOSIS OF SINUSITIS C CALVIN FOX, *Pennsylvania M J* 52 136 (Nov) 1948

The author points out, first, that the diagnosis of sinusitis is, too often, erroneously made by both the general practitioner and the otolaryngologist, second, that many of the symptoms and some of the physical findings in cases of sinus infections are also often present in cases in which the sinuses are free from infection. To cases of this kind the term sinusitis or pseudosinusitis could well be applied. Only by a careful history, consideration of the symptoms and intranasal and special physical examinations by physicians who are thoroughly trained and experienced in evaluating them, can a proper differential diagnosis be made.

In order to reduce the too casual use of the term sinusitis, it should be kept in mind that patients who have frequent or persistent headache, facial pain, excessive nasal or postnasal discharge or nasal obstruction, in various combinations, are sufficiently distressed, and many present a diagnostic problem difficult enough to justify the combined skills of the internist, the roentgenologist and the otolaryngologist.

LANDIS, Reading, Pa

### Miscellaneous

FUNDAMENTALS IN THE TREATMENT OF COMMUNICATIVE DISORDERS CAUSED BY HEARING DISABILITY II MIRIAM D PAULS and WILLIAM G HARDY, *J Speech & Hearing Dis* 13 97 (June) 1948

The treatment of communicative disorders caused by hearing disability involves the closest coordination of medical and nonmedical services. Complete diagnostic evaluation includes an otologic examination, a full series of hearing tests, psycho-acoustic and psychosocial examination and a thorough case history. Special attention is paid to the patient's communicative habits, his attitudes and behavior in typical communicative situations.

The terms deaf, hard of hearing, etc are not physiologically sound. It is convenient to refer to these, instead, as marginal, moderate and profound hearing loss. Out of almost 5,000 service personnel and veterans known to the authors, fewer than a dozen were so affected that they could not profit from the use of a hearing aid and retraining with amplified sound. The group with mild loss of hearing has the greatest difficulty in adjusting to the communicative problems.

Several guide lines must be followed in working with persons with hearing disabilities. First, the doubts, confusions and questions of the handicapped person must be faced squarely. Second, the person must have ample opportunity to learn to listen to amplified sound, center his attention in ambient noise, extend the limits

of his tolerance for loud sound and to utilize every possible auditory cue Third, once the choice of hearing aid has been determined, the person must learn to use it in a wide variety of situations Fourth, he must understand the role of speech reading Fifth, there should be sufficient instruction in the fundamentals of articulation and voice production to insure his retention of adequate habits Sixth, problems of psychosocioeconomic adjustment should be discussed freely

PALMER, Wichita, Kan

DIAGNOSIS AND PROGNOSIS IN CLEFT PALATE SPEECH CLAUDE E KANTNER,  
J Speech & Hearing Disorders **13** 211 (Sept) 1948

Nasality in speech at present is still a subjective phenomenon The degree of nasality does not seem to be directly related to the amount of air escaping through the nose or the degree of opening of the soft palate Nasality in cases of cleft palate cannot be dealt with intelligently on the assumption that it is simply a matter of repairing the soft palate and then learning to use it Devices for showing nasality may be very valuable as means of teaching but are not valuable or reliable as detectors of nasality It is necessary to observe the speech patterns, the speech organs and the case history in order to predict a proper series of technics An outline of the proper procedure in diagnosis is presented The goal for every person with cleft palate should be to avail himself of the best possible speech training commensurate with his needs, physical limitations, mental ability and potential contribution to society The author believes that medicine and surgery are both closer to this goal than are speech clinicians

PALMER, Wichita, Kan

TECHNIQUES IN THE MANAGEMENT OF APHASICS VIVIAN M SHEEHAN,  
J Speech & Hearing Disorders **13** 241 (Sept) 1948

Sheehan reports a case, together with a general description of clinical management of aphasia, and reaches the following conclusions

- 1 The patient with aphasia can learn without the use of fatiguing drill
- 2 He must work toward specific and well defined goals
- 3 He must realize he cannot reach perfection or normal speech
- 4 The clinician must differentiate between the severity of the aphasia and that of the handicap
- 5 Definite phrases should be taught, which should be used automatically
- 6 Every effort should be made to reduce and simplify the task The person with aphasia should not be handled in any way which promotes competition between different patients, nor should any clinician ever put the responsibility for recovery on the person with aphasia

PALMER, Wichita, Kan

ANTICIPATORY SPEECH RESPONSES IN CHILDREN WITH ARTICULATORY DEFECTS  
MARY ELLEN HULL, J Speech & Hearing Disorders **13** 268 (Sept) 1948

Thirty-two public school children, ranging in age from 5 to 12, with articulatory defects were compared with 14 normal controls of the same age and general intelligence A series of tests of repetition of vowels in nonsense syllables and words were given individually to each child in an effort to describe a phenomenon observed at the Institute of Logopedics known as the anticipatory response

1 In children with articulatory defects, production of each syllable was altered to a much greater extent when repeated in an anticipatory manner than when there was a delay between the stimulus sound and the speech response  
2 The anticipatory speech response is not limited to children with articulatory defects  
3 One child who was nervous, distractible and of below average intelligence made such responses  
4 Any child with an articulatory defect who had anticipatory reactions of sound could be taught to inhibit these reactions

The anticipatory speech response is defined as that type of response in which the child has an overrapid sound reaction in speech to the stimulus of a non-sense syllable by the examiner, and the child's reaction apparently occurs without conscious study of production. In the normal child and in the child with articulatory defect the usual response is produced with a considerable delay between the utterance of the syllable by the examiner and the response by the child

PALMER, Wichita, Kans

THE CELLULAR AND HUMORAL FACTORS INFLUENCING CONSTITUTIONAL RESISTANCE AND THE DEVELOPMENT AND CONTROL OF LOCAL LESIONS  
CHARLES A DOAN, *Laryngoscope* 58 879 (Aug) 1948

Constitutional resistance and the development of antibodies are important factors in any form of disease, often determining whether a treatment results in success or failure. Since virus infection apparently inhibits the cellular elements required to combat streptococci, a streptococcic infection will be much severer, and in some cases even fatal in the presence of a virus.

Nutritional deficiencies also contribute to loss of constitutional or cellular resistance. Lack of folic acid (pteroyl glutamic acid) and other vitamins, for example, will lower the resistance, as shown in experiments with monkeys. The spleen also plays an important role in the body's defense, being a reservoir for blood cells and a conservator of and storage depot for the basic materials from which the continuous new supply of blood cells must come.

HITSCHLER, Philadelphia

USE OF A NEW ANTIHISTAMINIC COMBINATION IN THE TREATMENT OF ALLERGIC DISORDERS. EARL B BROWN AND FREDERICK W BROWN, *New York State J Med* 48 1465 (July 1) 1948

This survey of 121 cases was made under the auspices of the Committee on Therapy of the American Academy of Allergy. The authors assume at the outset that an antihistamine drug is accepted as useful in allergic conditions. But there have been disturbing side reactions, namely drowsiness, nausea, "heart-burn," shakiness, dizziness, gastrointestinal symptoms, dryness, wheezing and spasm of the salivary duct. A new chemical combination of aminophylline U S P and diphenhydramine hydrochloride (hydryllin®) gives some hope of overcoming these objections. One tablet (25 mg of diphenhydramine hydrochloride) was given three or four times daily after meals and was increased as necessary, but not more than 8 tablets were given daily. Of 97 patients, 80 per cent showed definite improvement. Of the adult patients with asthma 82 per cent showed improvement.

Side effects were notably reduced as compared with those occurring with diphenhydramine hydrochloride used alone.

VOORHEES, New York

## News and Comment

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### **COURSE IN OTOLARYNGOLOGY, WASHINGTON UNIVERSITY SCHOOL OF MEDICINE**

An eight month's course in otolaryngology will be given by the Washington University School of Medicine from Oct 3, 1949 to June 1950

Further information may be procured from the assistant dean, Dr Merl J Carson, Saint Louis 10

### **COURSE IN CLINICAL AUDIOMETRY, STATE UNIVERSITY OF IOWA COLLEGE OF MEDICINE**

An intensive two week course in clinical audiometry will be offered at the State University of Iowa College of Medicine, from June 14 to 28, 1949. The course will be conducted daily from 8 00 a m to 5 00 p m and will include lectures on audiometry, lip reading, speech training for the hard of hearing, psychologic problems of the acoustically handicapped and clinical otolaryngology, laboratory work, including observation on and participation in hearing testing and hearing aid fittings for clinical patients in the Department of Otolaryngology and Oral Surgery, State University of Iowa Hospital, observation of the university's comprehensive speech pathology program, and special lectures and demonstrations by Prof John S Steinberg, of the Bell Telephone Laboratories, and Mrs Bernice Rutherford, of the Rehabilitation Center, St Paul

One of the Iowa Hearing Clinics, concerned with the medical, psychologic, speech, audiometric and social work approaches to cases assembled by the Department of Otolaryngology and Oral Surgery, the Iowa State School for the Deaf, and the Speech Clinic, will be scheduled during the intensive course

For further information, address Prof Wendell Johnson, Director, Speech Clinic, State University of Iowa, Iowa City

## Book Reviews

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**Oral Anatomy** By Harry Sicher, M D Price, \$15 Pp 500 St Louis The C V Mosby Company, 1949

This book is written especially for the dental student to supplement books on human anatomy which are more detailed and cannot devote space to allied subjects. It accomplishes much in bridging the gap between theory and practice by emphasizing the anatomic basis for many practical procedures used by dentists and oral surgeons.

It has two major sections—one, on the usual descriptive anatomy, stressing structures closely allied to work in dentistry, the other, on regional and applied anatomy. The latter section is excellently written and explains practical procedures on an anatomic basis, so that the student no longer has to follow fixed methods but can evolve his own by understanding the anatomic reasons for them. There are numerous fine pictures and diagrams depicting clearly the author's intentions. Several sections are exceptionally worth while to the otolaryngologist, these concern the temporomandibular articulation, local anesthesia and the ligations of the vessels in the head and neck. This book supplies important information in a clean, concise and simple manner.

**A Concise Clinic of Ear, Nose and Throat Diseases** By Erhard Luscher, Professor of Ear, Nose and Throat Diseases and Director of the University Clinic of Ear, Nose and Throat Diseases, Basel, Switzerland Cloth Price, 54 francs Pp 513, with 201 illustrations, many of which are colored Basel, Switzerland Benno Schwabe & Company, 1948

This book was written primarily for the student and the general practitioner. The matter is admirably presented, concisely, and yet every important phase of otorhinolaryngology is covered. The work is divided into three parts. The first part deals with the anatomy and the physiology of the ears, the nose and the throat. The second part is devoted to a detailed description of various methods of examining the ears, the nose, the throat and the larynx, and this description is graphically supplemented by many photographs and a careful detailed report of the normal findings. The third part deals with pathologic conditions. Each disease is described from the standpoint of cause, symptoms, course, physical findings, diagnosis, treatment and prognosis. Emphasis is placed on medical and conservative treatment, and the role of the antibiotic substances and the sulfonamide compounds is evaluated. Surgical intervention, where indicated, is discussed briefly—more or less in outline form.

The entire subject is clearly and succinctly presented, in logical sequence, and this makes extremely easy reading. Although the book was intended primarily for the student and the general practitioner, it has real value for the specialist.

# Directory of Otolaryngologic Societies \*

## INTERNATIONAL

### FOURTH INTERNATIONAL CONGRESS OF OTOLARYNGOLOGY

President Dr V E Negus, London, England  
General Secretaries Dr F C W Capps and Dr W A Mill, 45 Lincoln's Inn  
Fields, London, W C 2  
Place London Time July 18-23, 1949

### SECOND PAN-AMERICAN CONGRESS OF OTO-RHINO-LARYNGOLOGY AND BRONCHESOPHAGOLOGY

President Prof Justo Alonso  
Secretary Dr Chevalier L Jackson, 255 S 17th St, Philadelphia 3  
Place Montevideo Time January 1950

## NATIONAL

### AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON LARYNGOLOGY, OTOTOLOGY AND RHINOLOGY

Chairman Henry B Orton, 224 Delavan Ave, Newark, N J  
Secretary Dr J Milton Robb, 1553 Woodward Ave, Detroit, Mich  
Place Atlantic City, N J Time June 6-10, 1949

### AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Conrad Berens, 35 E 70th St, New York  
President-Elect Dr J Mackenzie Brown, 1136 W 6th St, Los Angeles 14  
Executive Secretary-Treasurer Dr William L Benedict, 100-1st Ave Bldg  
Rochester, Minn

### AMERICAN BRONCHO-ESOPHAGOLOGICAL ASSOCIATION

President Dr Paul Holinger, 700 N Michigan Ave, Chicago 11  
Secretary Dr Edwin N Broyles, 1100 N Charles St, Baltimore  
Place Drake Hotel, Chicago Time April 18-20, 1949

### AMERICAN LARYNGOLOGICAL ASSOCIATION

President Dr Frederick T Hill, 177 Main St, Waterville, Maine  
Secretary Dr Louis H Clerf, 1530 Locust St, Philadelphia 2  
Place Biltmore Hotel, New York Time May 16-17, 1949

### AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOTOLOGICAL SOCIETY, INC

President Dr John J Shea, 1018 Madison Ave, Memphis, Tenn  
Secretary Dr C Stewart Nash, 708 Medical Arts Bldg, Rochester 7, N Y  
Place Drake Hotel, Chicago Time April 18-20, 1949

## SECTIONS

Eastern—Chairman Dr Harold G Tobey, 403 Commonwealth Ave, Boston  
Southern—Chairman Dr Watt W Eagle, Duke University, Durham, N C  
Middle—Chairman Dr Dean M Lierle, University Hospital, Iowa City  
Western—Chairman Dr Leland G Hunnicutt, 98 N Madison Ave, Pasadena,  
Calif

### AMERICAN OTOTOLOGICAL SOCIETY

President Dr Marvin F Jones, 121 E 60th St, New York  
Secretary Dr Gordon D Hoople, Medical Arts Bldg, Syracuse 3, N Y  
Place Biltmore Hotel, New York Time May 18-19, 1949

### AMERICAN OTORHINOLOGIC SOCIETY FOR THE ADVANCEMENT OF PLASTIC AND RECONSTRUCTIVE SURGERY, INC

President Dr Samuel F Kelley, 47 E 61st St, New York 21  
Secretary Dr Norman N Smith, 291 Whitney Ave, New Haven 11, Conn

### AMERICAN SOCIETY OF OPHTHALMOLOGIC AND OTOLARYNGOLOGIC ALLERGY

President Dr Rea E Ashley, 384 Post St, San Francisco  
Secretary-Treasurer Dr Joseph Hampsey, 806 May Bldg, Pittsburgh 22

\* Secretaries of societies are requested to furnish the information necessary to keep this list up to date

## FUNCTIONING OF THE AIR CELL SYSTEM OF THE MASTOID PROCESS IN AUDITION

PHILIP G MACDONALD, M D  
NEW YORK

### THE CONDUCTION SYSTEM

PRACTICALLY all significant sounds are made by animals or objects separated from the listener by space containing air and are therefore air conducted. Most, if not all, the air-conducted sounds are conveyed to the listener through the external auditory meatus. The auricle and external canal collect sound vibrations from the air, and the middle ear modifies and transmits these vibrations to the internal ear.

The sound vibrations which have been collected and condensed in the external canal cause the tympanic membrane to vibrate, and its vibrations in turn are transmitted through the auditory ossicles to the inner ear. The eustachian tube, the tensor tympani muscle and the stapedius muscle are accessories which help to focus and aid in the transmission of sound vibrations through the middle ear. The vibrations passing through the tympanic membrane and the auditory ossicles are reduced considerably in amplitude but are correspondingly increased in force, that is, the vibrations which hit the ear drum are of relatively large excursion but weak, and the system of levers in the ossicular chain greatly lessens this excursion but correspondingly greatly increases the force of these vibrations. The decrease of amplitude and the increase of force are most essential, as the inertia of the fluid in the scala vestibuli and the scala tympani has to be overcome, also, the elasticity of the membrane over the round window must be overcome before any vibrations can be transmitted to the organ of Corti. The air is a relatively thin medium as compared with the fluid in the cochlea, and much more force must of necessity be applied to activate the cochlear fluid than to activate an equal volume of air. To counteract this, however, there is not only the favorable leverage in the ossicular chain but the difference between the area of the tympanic membrane and the area of the oval window, that is, the size of the oval window is only a small fraction of that of the tympanic membrane and must therefore receive proportionately much more powerful impulses. To summarize—the impulses at the tympanic membrane are comparatively weak but of great amplitude as compared with the vibrations of the



stapes The sound-transmitting system of the external and the middle ear is designed to intensify the sound vibrations by decreasing the amplitude and increasing the force of the vibrations and by concentrating them at one single point, the oval window

The tympanic membrane must be free to react to sound waves that reach it through the external auditory meatus, and these waves must be transmitted without interference through to the fluid of the scala tympani if normal hearing is to result There are several factors which facilitate the free movement of the membrana tympani and these are

- 1 The preservation of the neutral intratympanic pressure, which is achieved by the periodic opening and closing of the eustachian tube

- 2 The equalization of the slight changes of intratympanic pressure caused by the action of the tensor tympani and stapedius muscles, which is accomplished by movement of the flaccid portion of the membrana tympani

- 3 The neutralization of any change of the balance of the intratympanic and extratympanic pressure which might arise from the slight vibratory movement of the membrana tympani This neutralization occurs because of the easy displacement of the flaccid Shrapnell's membrane

- 4 The movement of the malleus on the hinges—the anterior and posterior malleolar ligaments—which is permitted by the flaccid portion of the drum membrane If Shrapnell's membrane were a tight membrane, it would press on the body of the malleus and prevent its movement

- 5 The absorption of pent-up sound waves It is well known that a vibrating membrane over a closed pocket causes vibrations to build up in the pocket and that these in turn greatly interfere with the vibrating membrane The middle ear is a closed pocket except when the eustachian tube opens intermittently If there were no means supplied by nature to absorb these pent-up vibrations, they would build up and interfere with weak excursions of the membrana tympani, and considerable loss in hearing would result Nature has, however, supplied a fine sound-absorbing system in the air cells of the mastoid process

#### THE AIR CELLS OF THE MASTOID PROCESS

In the mastoid portion of the temporal bone the air cells are arranged in definite series of cells, and each of these series opens either into the antrum or into the middle ear directly This serial arrangement is ideal for the disbursement and absorption of sound waves One of the best sound-absorbing substances known is moist mucous mem-

brane,<sup>1</sup> and the air cells of the mastoid process are all lined with moist mucous membrane. In no case does a cell of this area normally communicate directly with the outside of the skull, the communication is indirectly achieved through the middle ear and the eustachian tube.

It has been suggested that the cells of the mastoid process might act as resonators, but they are not built like resonating bodies. It has also been suggested that the air mass of the mastoid process might act as a cushion to allow greater freedom of excursion of the tympanic membrane. This, however, is unlikely as the equalization of air is taken care of by the eustachian tube and to a lesser extent by the flaccid Shrapnell's membrane.

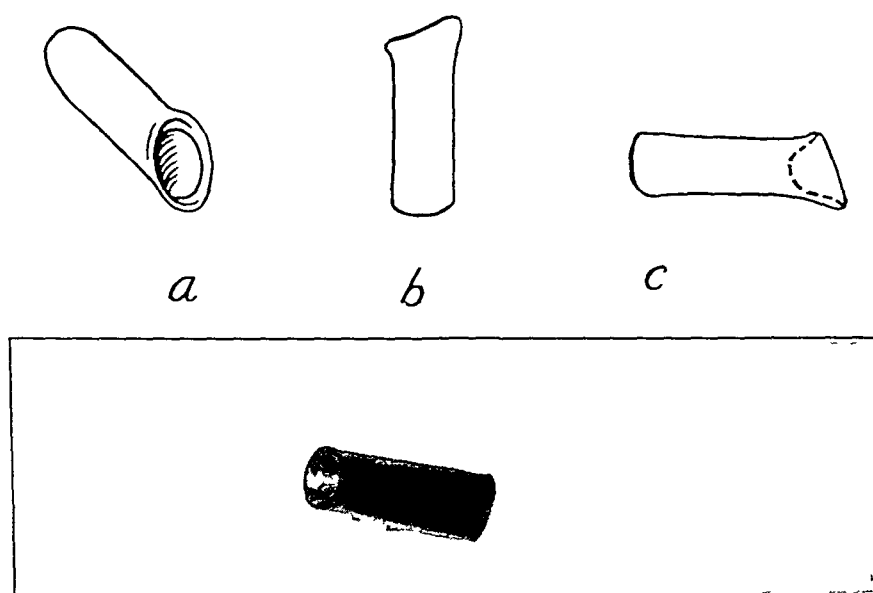


Fig 1—Rubber insert showing (a) face view of the vibrating membrane (artificial ear drum), (b) cross section showing one side projecting so that it will contact the auditory area around the stapes, (c) the concave invaginated membrane. This membrane when put in the ear is convex over the middle ear, being exactly opposite to the cone of the ear drum, which is concave in effect. The side walls are pliable and of sufficient length to hold the artificial ear drum in position.

#### CLINICAL OBSERVATIONS THAT INDICATE A FUNCTION OF THE AIR CELLS IN HEARING

I have been inserting artificial ear drums<sup>2</sup> (fig 1) to aid the hearing of patients who have lost their ear drums. The face of the artificial ear drum is concave and slanted so that one side projects a millimeter or so beyond the other. This projecting side is inserted in the ear so that it comes in contact with the acoustic area in the region of the stapes. After one of these inserts has been applied,

<sup>1</sup> Finch, W S H. Personal communication to the author.

<sup>2</sup> The ear drums used are modifications of the inserts introduced by Dr Max E Pohlman, of Los Angeles.

the hearing varies in the patient from time to time. In an endeavor to find out the cause of this variation a pertinent finding was made. When there was a crust or other debris in the aditus, the patient's hearing was definitely below expectation but when the interfering matter was cleaned out and the insert introduced, the hearing improved considerably. Subsequent to this observation, I packed petrolatum gauze into the aditus so that no part of the pack could come in contact with the inserted artificial ear drum. I then made an audiogram of the patient's hearing (curve *B*, fig 2). Then I removed the artificial ear drum and the gauze pack and made a second audiogram (curve *C*). I inserted the artificial ear drum (the aditus ad antrum was clear) and made a third audiogram (see curve *A*).

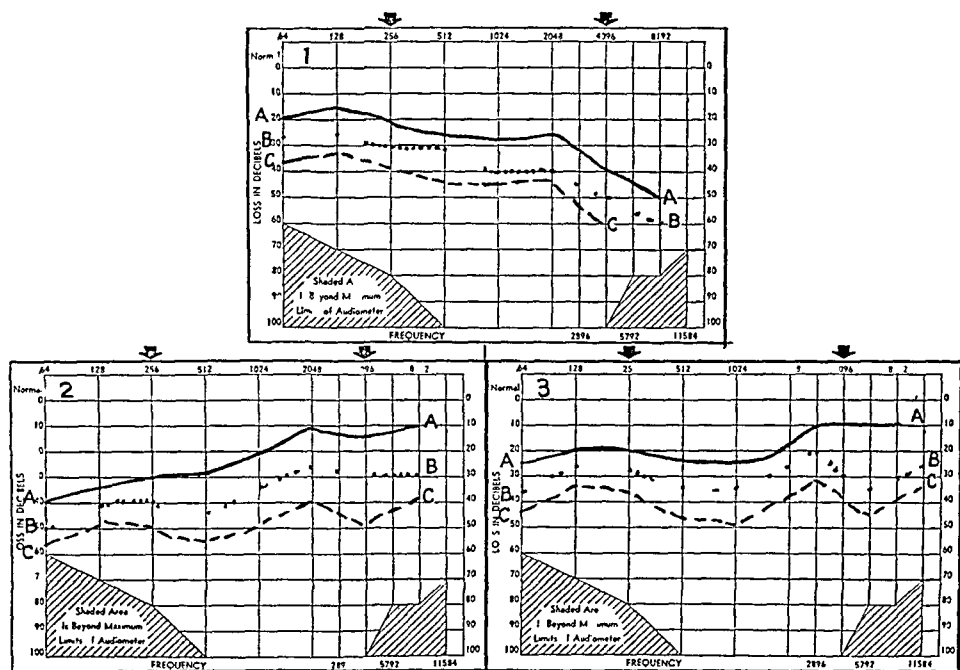


Fig 2—These audiograms were made on people who had lost their ear drums. 1, patient A S C, 2, patient A S S, 3, patient S A D. The *A* curves represent the hearing when the aditus ad antra were clear and the described artificial ear drums were inserted correctly in the ears tested. The *B* curves represent the threshold of hearing when the aditus ad antra were obstructed with a plug of petrolatum gauze so placed that no part of it could come in contact with the correctly inserted artificial ear drums. The *C* curves represent the threshold of hearing when the aditus ad antra were clear and the artificial ear drums had been removed.

When these audiograms are examined, one sees that with the ears empty (that is without inserts) the loss of hearing is sufficient to put the hearing of these patients into the unserviceable class. When the aditus ad antra are blocked and inserts introduced and the patient's hearing tested, the audiograms indicate that the hearing does not quite come up to the serviceable level, but when their aditus ad antra are

cleared and inserts introduced the hearing becomes serviceable In figure 2 I show the audiograms of only 3 patients, but this experiment was repeated on many patients and the results were always the same

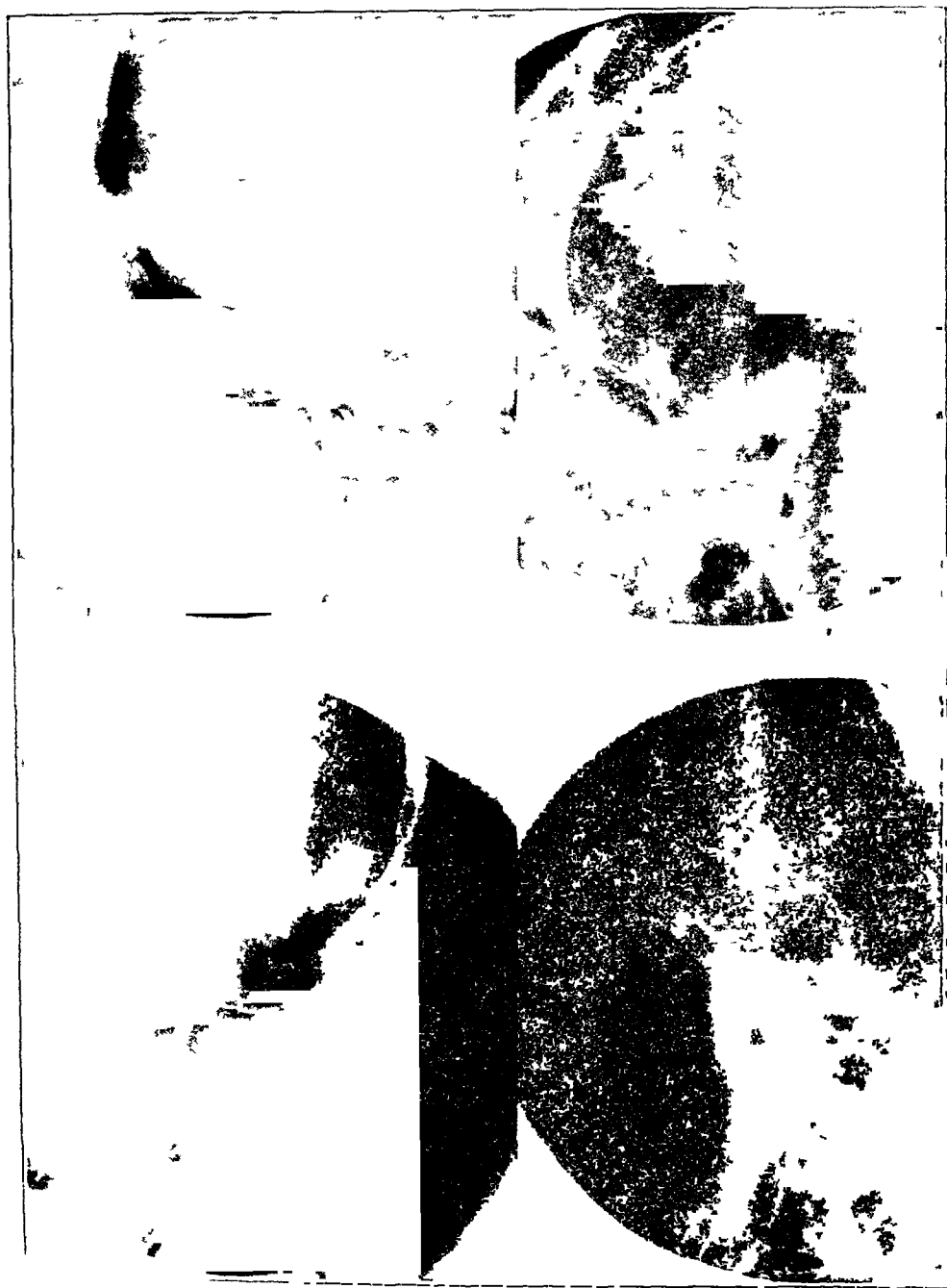


Fig 3—Roentgenograms of the mastoid processes of A S S (above) and S A D (below) taken at the time at which they were tested under the conditions described in the legend of figure 2

I had roentgenograms made of the mastoid processes of 2 patients and they are reproduced in figure 3 These mastoid processes are

definitely sclerotic and do not at all suggest a resonance factor as the cause of the improvement when the aditus ad antra were cleared. They do, however, suggest that the cells of the mastoid processes might act as "sound-absorbing chambers."

I took this problem to a sound engineer,<sup>1</sup> and he told me that as long as cells were present in the sclerotic mastoid process this would, like the normally pneumatic mastoid process, act as a sound-absorbing chamber but that the structure of neither was suitable for a sound resonator. I then decided to build an apparatus to demonstrate this fact.

#### EXPERIMENT

After a great many failures, an apparatus was constructed that responded to the frequencies 64 to 8192 sufficiently well to be used

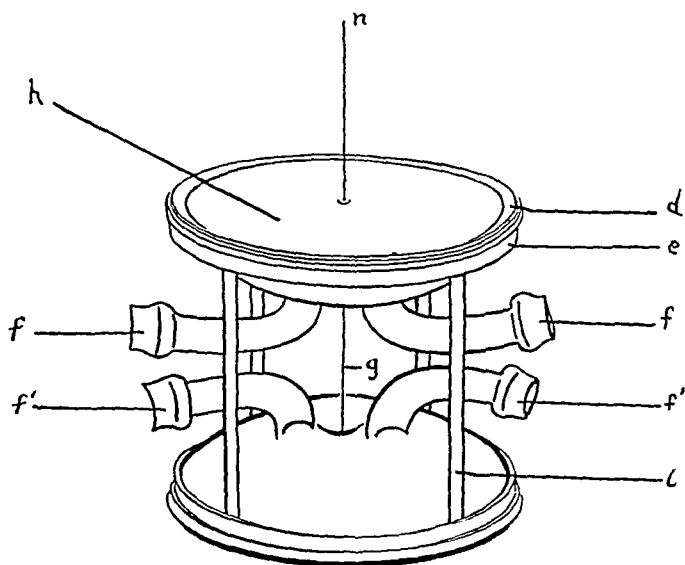


Fig 4—Diagram of the head of the instrument. There are two brass frames holding the diaphragms. They are held together by four supports (*i*) so that the membranes will be exactly 2 inches (5 cm) from each other. The air space between the frames is occupied by the ducts (*f*) and (*f'*). This air space also allows for dissemination of any sound waves that might escape around the wire (*g*) (see *k* in fig 7). This wire is 0.0025 inch (0.064 mm) in diameter and the opening through which it passes (*k*, fig 7) is 0.025 inch (0.6 mm) in diameter. This difference in diameter is necessary so that the wire will not touch the sides of the opening when it is vibrating. The bodies of these frames are of cast brass and sufficiently heavy so that they do not vibrate easily. The rim (*d*) is screwed onto the shoulder (*e*) holding the diaphragm (*h*) in position. The fine wire (*g*) is glued exactly to the center of the diaphragms with airplane cement (*n*).

experimentally to determine whether the cells of the temporal bone act as resonators or as sound-absorbing chambers for the human ear. Pictures and diagrams of the apparatus used are given in the following pages.

In referring to the instrument I shall call the portion containing the vibrating diaphragms the head (fig 4) and the portion which is next to the person the

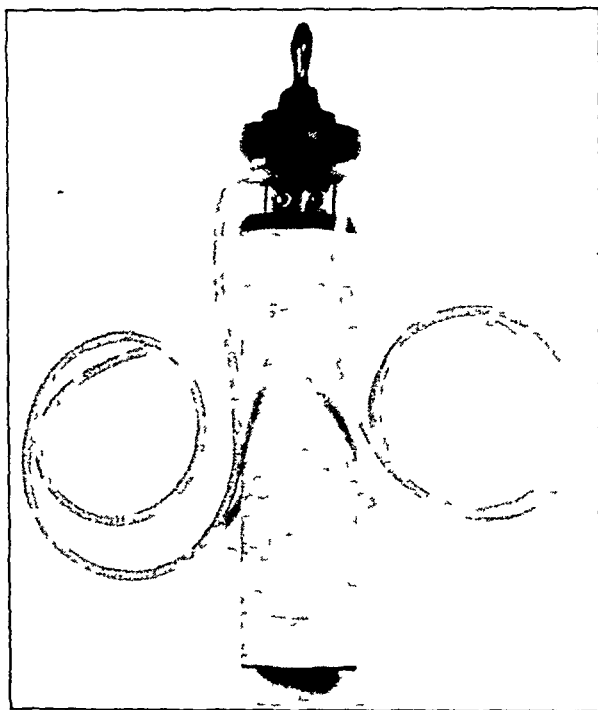


Fig 5—The instrument



Fig 6—The instrument in use

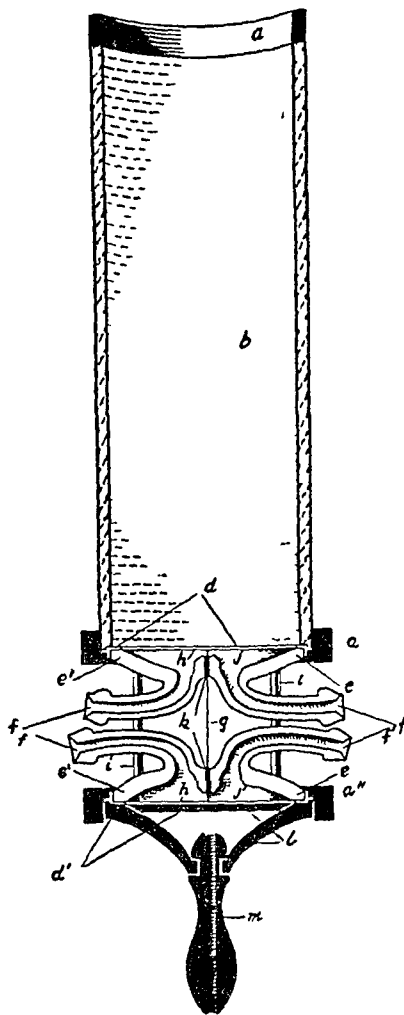


Fig 7—Diagram of the instrument (a) Soft rubber shoulder cemented to a cardboard tube (b) This is to lessen extraneous noises when it is brought in contact with the ear piece of the audiometer

(a') Soft rubber shoulder to hold the cardboard tube (b) to the head of the instrument (see fig 4)

(a'') Soft rubber shoulder to hold the ear piece to the head of the instrument

(b) Cardboard tube 8 inches (20 cm) in length and 2 inches (5 cm) in diameter

(d) Rim which screws onto shoulder (e) to hold diaphragm *h* in place

(d') Second rim to hold diaphragm *h'* in place

(e and e') Brass shoulders to which are attached diaphragms *h* and *h'*

(f) Tubes leading to the space behind the distal diaphragm *h*. To these are attached the sound-absorbing tubes, the resonating tubes or the lead plugs, whichever are being used at the particular part of the experiment

(f') Tubes leading to the space behind the proximal diaphragm. To these are attached soft rubber tubes 2 feet (61 cm) long to prevent any audiometric sounds from entering

(g) Nickel-chromium alloy wire 0.0025 inch (0.064 mm) in diameter and exactly 2 inches (5 cm) long connecting diaphragm *h* to diaphragm *h'*. This is under only enough tension to keep it straight

(*h* and *h'*) Diaphragms 0.001 inch (0.025 mm) thick and 2 inches (5 cm) in diameter, which are fastened to *e* and *e'*. These diaphragms must be of uniform thickness and free from all wrinkles or defects

(*i* and *i'*) Metal bars which hold the head together

(*j* and *j'*) Air space behind the distal and proximal diaphragms

(*k*) Drill hole in a direct line passing through the proximal and distal frames. It was drilled in a straight line on a lathe and is 0.025 inch (0.6 mm) in diameter

(*l*) Rubber cone which collects the vibrations set up by diaphragm *h'* and centers these to the ear piece

(*m*) Ear piece for detection of sound waves passing through the instrument from the audiometer. The ear piece (*m*) must not be forcibly held in the ear of the person undergoing this test, as it raises the threshold of the instrument, especially in the high tones. This is likely due to the air's being compressed in front of the distal diaphragm (*h*) and also to the changing of the space *j* into a closed space so that the vibrations build up in front of this diaphragm, interfering with its movement. The ear piece must therefore always be held in the external auditory canal of the person being tested so that a passage of escape is present around the hard rubber ear piece

proximal portion (figs 5 and 6) and that which is nearest the audiometer ear piece the distal portion (figs 5 and 6)

It was found that the threshold of resistance in this instrument (fig 7) is 50 decibels when the diaphragms are not connected (i e, the instrument is assembled, but there is no wire connecting the two vibrating diaphragms), and any tone that approaches this level must be considered as not passing through the connected diaphragms but through the body of the instrument. It was also found that the diaphragms in this instrument must fall within definite limits of thickness and size

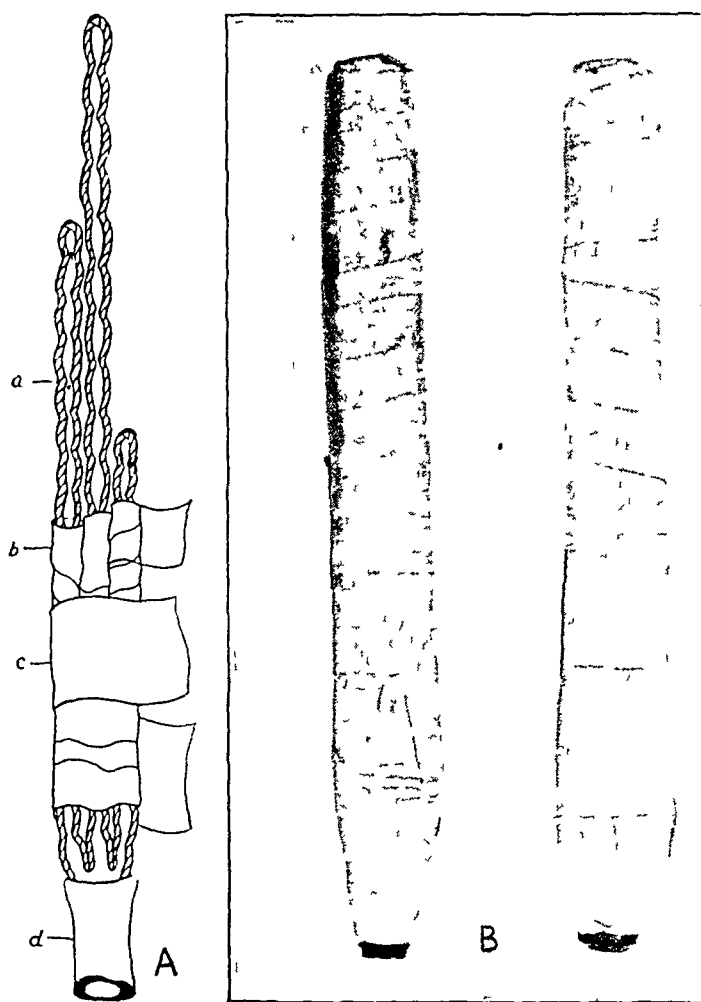


Fig 8—The sound-absorbing applicators are built as illustrated (a) Soft felt sewed so that it makes a series of air cells (b) Covering of scotch tape. Each series of cells is bound with scotch tape, care being taken not to obliterate the lumen of the duct. There are several layers applied to each tube of cells to give them rigidity (c) The tubes are held together by an outside binding of scotch tape (d) Soft rubber tip so that these tubelike series of cells may be attached to the tubes (f in figs 4 and 7) of the head of the instrument. It will be noted that each series of cells empties into a cavity to which is attached the rubber connecting tube (d)

and that the connecting wire must be of a definite length and thickness and under definite tension if the instrument is to give satisfactory responses. The best responses are given when diaphragms 2 inches (5 cm) in diameter and 0.001 inch (0.025 mm) thick are used. The fine wire that connects the diaphragms must



not exceed 0.0025 inch (0.064 mm) in thickness and must be exactly 2 inches (5 cm) long. The hole drilled through the frames behind the diaphragms, through which this wire passes, is 0.025 inch (0.6 mm) in diameter. This causes a slight leak of sound but is necessary so that the wire will not touch the sides of the opening when it vibrates, otherwise it will not conduct the vibrations to the second diaphragm (fig 7). This drill hole was made on a lathe, and both holes were drilled at once so that they would be in direct line with each other and directly through the center of the head of the instrument.

The frames that hold the diaphragms are of cast brass and are of sufficient thickness so that they do not vibrate easily to the audiometer tones. These two

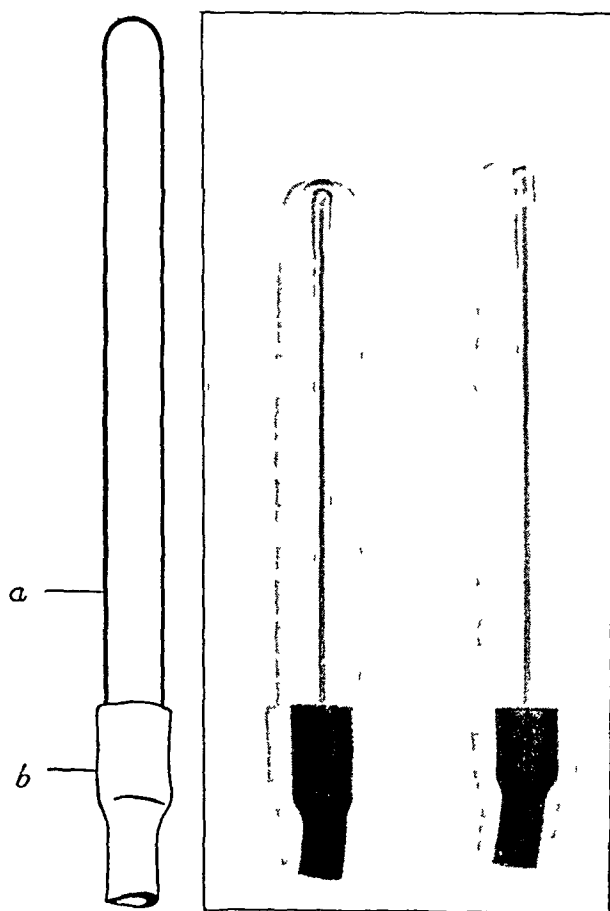


Fig 9—Resonating tubes are built as illustrated. (a) glass tube 7 inches (18 cm) in length and 5/16 inch (about 8 mm) in inside diameter, (b) soft rubber tubing by which these are attached to the distal tubes (f in figs 4 and 7) of the head of the instrument.

frames are held together by posts which are solid enough not to allow distortion of the head in handling. The two frames are really modified phonendoscope heads held with the diaphragms facing away from each other. They are held so that the diaphragms are exactly 2 inches apart. The air space between them is occupied by the ducts (see figs 4 and 5), to which are attached the sound-absorbing cells (fig 8), the resonating tubes (fig 9) or the lead stoppers (fig 10), whichever are being used in the test at that time. This air space between the two frames that hold the diaphragms also allows dissemination of any sound

waves that might travel through the openings through which passes the wire that connects the two diaphragms. These holes are 0.025 inch in diameter and the wire only 0.0025 inch in diameter. The wire is nickel-chromium alloy and has great tensile strength. The tension on the wire is only sufficient to keep it taut.

The distal side of the head of the instrument is attached to a paper fiber tube 2 inches (5 cm) in diameter and 8 inches (20 cm) long. This tube is capped with a soft rubber ring at the distal end of the tube as it comes in contact with the ear piece of the audiometer, and the rubber reduces any extraneous noises. To the proximal end of the head of the instrument is connected a cone which collects the vibrations set up by the second diaphragm below and concentrates these to a hard rubber ear piece. The ear piece is put into the ear of a person with normal hearing, and an audiometer ear piece is fastened to the distal end of the cardboard tube. The vibrations that reach the ear must therefore pass through the head of the instrument and activate the two diaphragms. With this setup an audiogram is made using the frequencies 64, 128, 256, 512, 1024, 2048, 4096 and 8192 double vibrations per second. It was impossible to get this instrument to function properly to frequencies beyond 8192. To be sure that the sounds do not enter the metal tubes in the space behind the proximal diaphragm two rubber tubes 2 feet (61 cm) long are attached to these tubes (fig. 5).

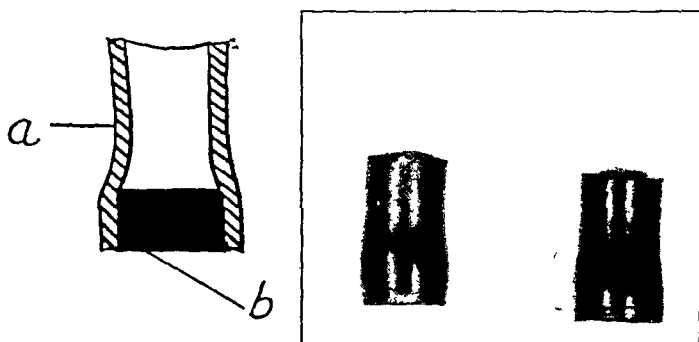


Fig. 10—(a) Soft rubber tube to hold lead plug (b) tightly against the distal tubes (f) of the head of the instrument and so produce a closed space behind the diaphragm (h). This allows vibrations to build up in the space (j) and so interfere with and distort the excursions of the membrane (h). (The small letters f, h and j refer to figures 4 and 7.)

To the tubes behind the distal side of the head are attached the sound-absorbing tubes (fig. 8), the resonating tubes (fig. 9) or the lead stoppers (fig. 10), whichever are used in the test being done.

The sound-absorbing tubes are made up of a series of cells which are lined with soft felt. There are three series to each set of tubes, and these series are of different lengths (fig. 8A). The resonating tubes are narrow glass tubes which were tested for resonating quality beforehand. They have short pieces of rubber tubing over their mouths so that they may be attached to the tubes (fig. 9) behind the distal diaphragm. The lead stoppers (fig. 10) are also in short pieces of rubber tubing so that they may be applied to the tubes behind the distal diaphragm (fig. 7) and block these tubes, making the cavity behind the distal diaphragm essentially a closed space.

Four audiometric thresholds were recorded for each person in this experiment.

Threshold A, to establish the person's regular hearing.

Threshold B, obtained by using the instrument described and lead stoppers (fig. 10) against the metal tubes leading to the air space behind the distal diaphragm.

Threshold *C*, obtained with the same setup as *B* except that the lead stoppers were removed and the resonating tubes (fig 9) were applied to the metal tubes leading to the air space behind the distal diaphragm

Threshold *D*, obtained with the same setup as the two preceding thresholds except that, instead of the stoppers or the resonating tubes, sound-absorbing tubes (fig 8) were attached to the metal tubes leading to the air space behind the distal diaphragm

These tests are recorded in figure 11. It will be noted that loss of sounds passing through the instrument is considerably less when the sound-absorbing mechanism is attached to the metal tubes leading to the

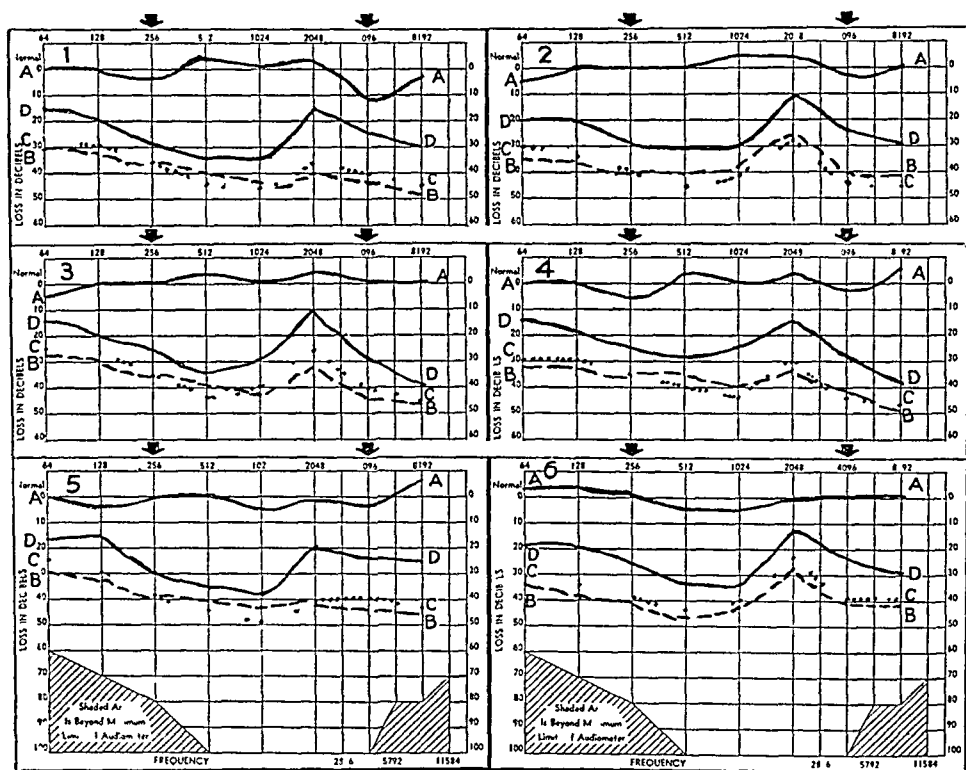


Fig 11—When the apparatus described was used, audiograms were obtained that show the energy in decibels necessary to activate the diaphragms and produce threshold hearing for persons with normal hearing (1) M P, (2) G P (3) C M, (4) B J, (5) H A, (6) O G. These six people were well acquainted with the audiometer and their responses should be accurate.

The curves represent *A*, regular audiometric readings, *B*, readings when the instrument was used with lead stoppers against the metal tubes leading to the air space behind the distal diaphragm, *C*, readings when the instrument was used with resonating tubes attached to the metal tubes leading to the air space behind the distal diaphragm, *D*, readings when the instrument was used with sound-absorbing tubes attached to the metal tubes leading to the air space behind the distal diaphragm.

air space behind the distal diaphragm than when the stoppers or the resonating chambers are attached to these tubes. This definitely shows that the vibrations of the diaphragm in the distal frame of the head of

the instrument were interfered with by the sound waves that built up behind it. The same thing will happen to the vibrations of the ear drum if the cells of the mastoid process are blocked off from the middle ear, and this explains why the artificial ear drums improve the patients' hearing much more when the *aditus ad antra* are clear !

The difference of the decibel readings in each of these audiograms gives a rather graphic idea of what sound waves building up behind a vibrating membrane will do. Nature has supplied a sound-absorbing mechanism in the air cells of the temporal bone to prevent this interference and distortion of sounds in the middle ear. In testing this instrument it was noted that distortion developed when the lead stoppers were used over the distal tubes (fig 10) between the two diaphragms. This is to be expected, as sound waves build up and interfere with one another. The distortion was most pronounced at 64 double vibrations, producing a tone some octaves higher. It usually was heard before the true tone was audible. When the sound-absorbing attachments were used instead of the lead stoppers there was no interference that could be detected.

The air cells have been destroyed in mastoidectomies with no consideration as to their function. In younger persons who have undergone simple mastoidectomy nature attempts to reform these cells, but in older persons, if the mastoidectomy has been fairly complete, the partial loss of cellular function is permanent. After a simple mastoidectomy in which the antrum has been left intact many of the cells left in the mastoid process at operation will continue to function, and good hearing may follow the operation. All the cells that connect with the middle ear and the antrum are never removed in simple mastoidectomy, so that a complete loss of cellular function never follows this operation. The slight loss of hearing following simple mastoidectomy in many patients is undoubtedly due to the loss of the function of the mastoid process described. Sclerotic mastoid processes may have satisfactory sound-absorbing qualities as long as there is cellularization. Persons whose mastoid processes are completely sclerotic, even if they have perfectly functioning cochleas, undoubtedly have a definite impairment of hearing due to the fact that there is sound interference in the middle ear lessening the force of the excursions of the tympanic membrane.

In the fenestra nov-ovalis operation many of the cells of the mastoid processes are sacrificed and the antrum is sealed off by the flap, so that the only sound-absorbing cells left are those that open into the middle ear directly. This produces interference reducing the excursions of the drum membrane and hence the acuteness of hearing that should be obtained in the ear operated on. This is especially true if there is an active fistula reaction when the drum membrane is touched.

If the drum membrane is bound down with adhesions over the prominence of the canal for the facial nerve, the sound interference in the middle ear will have little or no effect on the hearing, which in this event will be poor anyway

Day<sup>3</sup> advised otologists most earnestly not to do the complete mastoidectomy when performing fenestration, as the enlarged cavity would give rise to an echo phenomenon. The mastoidectomy cavity is much too small to produce an echo,<sup>1</sup> but the phenomenon he mentioned is undoubtedly produced by the vibrational interference and distortion of sound that occur in the middle ear in consequence of the destruction of the sound-absorbing air cells of the mastoid process

OBSERVATIONS THAT SUPPORT THE THEORY THAT SOUNDS  
ARE ABSORBED IN THE AIR CELLS

In 1945 Lempert<sup>4</sup> claimed that in 20 per cent of cases of so-called "frank nerve deafness" an improvement of hearing resulted from fenestration of the labyrinth. It is likely that there was a misjudgment of the cochlear reserve in these cases. Lempert depended at that time on the bone conduction test to give him an estimation of the so-called cochlear reserve. The bone conduction test does not give a correct estimation of the cochlear reserve in all cases, and further evidence that errors of classification are likely is given by some of the audiometric results of Lierle and Reger<sup>5</sup>. They reported audiograms of deafened persons showing markedly increased acuity for bone conduction and also audiograms showing disproportionate decrease in acuity for bone conduction.

In doing a bone conduction test, one usually places the bone conduction tip over the mastoid bone. Now if the mastoid process is functioning well, the sound produced by the bone conduction tip may be absorbed to a greater extent than usual by the cells of the mastoid process and not reach the cochlea as forcefully as it should. If the cells have heavy walls, the sounds may not be absorbed to as great an extent as usual and may give the impression of greatly increased bone conduction or high cochlear reserve. In reality the sound waves conducted through the mastoid cells in either case have been distorted

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3 Day, K. M. Appraisal of Fenestration Operation. Report of One Hundred Cases, *Arch Otolaryng* **44** 547 (Nov.) 1946

4 Lempert, J. Lempert Fenestra-Nov-Ovalis with Mobile Stopper. New Advance in Surgical Treatment for Clinical Otosclerosis Evolved as Result of Research Study of One Thousand Cases in Which Fenestration Has Been Performed During Last Seven Years, *Arch Otolaryng* **41** 1 (Jan.) 1945

5 Lierle, D. M., and Reger, S. N. Correlations Between Bone and Air Conduction Acuity Measurements Over Wide Frequency Ranges in Different Types of Hearing Impairment, *Laryngoscope* **56** 187, 1946

The cellular absorption of sound must be taken into account in these cases of so-called "frank nerve deafness," also in cases of disproportionate increase of bone conduction. Undoubtedly, the cases reported by Lempert were those in which the cellular absorption of sound was sufficient to give a paradoxical impression of the cochlear reserve, and were not really cases of nerve deafness at all.

I have noticed that in my patients whose labyrinths have been successfully fenestrated, the Weber test sound is referred to the ear operated on, and the bone conduction is improved as compared with the preoperative bone conduction. This is most likely due to the fact that many of the air cells of the mastoid process were destroyed during the fenestration. In my postoperative patients these two tests give the most pronounced results in those in whom I have removed most of the air cells. Undoubtedly, these results of the Weber test and the bone conduction test are due to the lack of absorption of the sound waves, which is due to the destruction of part of the air cells. In many of the patients on whom I have done fenestration of the labyrinth there is a progressive postoperative nerve type of degeneration, which may be due to an otosclerotic lesion advancing around the cochlea or may be due to trauma, as the protective faculties of the conductive apparatus have been destroyed at operation and the cochlea is exposed to sound trauma which may cause degeneration. In postoperative patients in whom the Weber test reverses itself (sound referred to the ear not operated on) there has already developed damage of the nervous apparatus, and this is further manifested by a higher threshold in the bone conduction audiometric reading. The closing of the fenestra does not alter the postoperative reference of the Weber test or the higher level of bone conduction so long as the cochlea is not damaged. To summarize—the Weber test sound is referred to the postoperative ear whether the fenestra is open or closed as long as the cochlear function is good, and the bone conduction threshold is lowered in the ear postoperatively whether the fenestra is open or closed, provided the cochlea has not been damaged. This is undoubtedly explained by the lessened absorption of sound waves following destruction of many of the air cells of the mastoid process.

After simple mastoidectomy the Weber test sound is always referred to the ear operated on, provided the cochlear function is good in this ear. This also is explained by destruction of the air cells of the mastoid process operated on and lessening of the sound absorption of this ear.

#### SUMMARY

The cells of the mastoid process are of great importance in hearing, for they act as sound-absorbing structures, absorbing the sound vibra-

tions that otherwise would build up behind the drum membrane and interfere with and distort its excursions. Undoubtedly, many cases of so-called "frank nerve deafness" diagnosed by tests of bone conduction are not cases of nerve deafness, and the audiograms are misleading. The air cells of the mastoid process may absorb vibrations when a bone conduction test is made and give an erroneous reading, or again, in cases in which heavy septums are present, may conduct sound waves much better than in the average case and thus suggest that the cochlear reserve is higher than it really is.

#### CONCLUSIONS

1 The air cell system of the mastoid process acts as a sound absorber to prevent sound waves from building up in the middle ear and interfering with the excursions of the drum membrane, distorting the transmitted sound waves.

2 The echo phenomenon reported by Day is undoubtedly due to the distortion that occurs in ears on which the fenestration operation has been performed, owing to loss of many of the sound-absorbing air cells of the mastoid process.

3 The bone conduction method of estimating the so-called "cochlear reserve" is not always dependable and may be misleading.

4 The present fenestration technic will have to be revised to preserve the air cells of the mastoid process, or the hearing threshold of patients undergoing this operation will never permanently approach the normal level.

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## ANTRAL WINDOW IN THE MIDDLE MEATUS

Experiments and Presentation of Cases in Which an Antral Window Was Made  
in the Middle Meatus of the Human Subject and No Additional  
Surgical Procedures Were Performed

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THE clinical research presented in this thesis was undertaken neither for the purpose of proving that the opening of a window into the maxillary antrum through the middle meatus is physiologically correct nor for the purpose of advocating such a procedure for drainage of the sinus. Rather, it was a matter of pure research to determine what occurs in an antrum and adjacent structures after the making of a middle meatal window. Pertinent experiments had been done on animals but not on the human subject.

The work discussed in this paper was done with some trepidation despite my recognition of the work of men who had adopted this surgical procedure as one of choice. Then, too, I had made an antral opening through the middle meatus before the publication of the excellent experimental work of Hilding, Proetz, Van Alyea, Lucas, Lierle and others, with good results. However, without the encouragement of some of the leading members of the Triological Society, it would have seemed unwise to reopen this controversial problem.

### HISTORICAL REVIEW

Because of the dearth of literature concerning the subject of making the antral window through the middle meatus, there are few salient facts to quote.

Ostrom<sup>1</sup> was perhaps the first in this country to advocate forcefully the making of middle meatal windows. Brawley and Pierce, in discussing Ostrom's essay, voiced their approval of his method of ventilating and draining the maxillary sinus.

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From the Department of Otolaryngology, Vanderbilt School of Medicine.  
Presented as a candidate's thesis to the American Laryngological, Rhinological and Otolological Society.

<sup>1</sup> Ostrom, L. Ventilation Rather Than Drainage Essential for the Cure of Sinus Disease with Special Notes on the Antrum of Highmore, Illinois M. J. 24 347-352 (Dec.) 1913.



Rethi,<sup>2</sup> Freer,<sup>3</sup> Sluder,<sup>4</sup> Canfield<sup>5</sup> and Hirsh<sup>6</sup> made large comprehensive antral windows by removing the antral wall of both the inferior and the middle meatus but without removing the inferior turbinate bone

Sewall<sup>7</sup> advised that one should, as a routine, remove the middle meatal wall in surgical treatment of the ethmoid and sphenoid sinuses when doing radical antrotomy. He further advised that the middle meatal wall be removed when isolated disease of the antrum is present.

Hilding,<sup>8</sup> in discussing the results of his experimental work on the maxillary sinus in rabbits, stated, "The experiments indicate that windows made at or near the ostium interfere so seriously with the normal sinus physiology that the sinus becomes infected as a result. All three of those in which the window was made at the ostium became infected postoperatively." He added, "It cannot be concluded from these experiments that exactly the same results would occur in the sinuses of other species or in man."

Proetz<sup>9</sup> stated, "To regard the ostium simply as an opening into the sinus, which can be roughly handled and even enlarged with impunity, is to court failure in establishing hygiene of the region."

Zuckerkindl<sup>10</sup> suggested that the middle meatus be used for an opening into the maxillary sinus because of its membranous structure.

Siebenmann<sup>11</sup> systematically made openings into the antrum through the middle meatus and reported good results. He made his first opening

2 Rethi, L. Eine Radicaloperation der Kieferhöhle von der Nase her zur Behandlung hartnackiger Empyeme, *Wien med Wchnschr* **51** 2436-2439, 1901, Die Radikaloperation der Kieferhöhlenentzündungen von der Nase her, *Wien klin Wchnschr* **21** 142-149, 1908

3 Freer, O. T. The Antrum of Highmore. The Removal of the Greater Part of Its Inner Wall Through the Nostril, for Empyema, *Laryngoscope* **15** 343-349 (May) 1905

4 Sluder, G. A Modified Mikulicz Operation Whereby the Entire Lower Turbinate Is Sawed in Intranasal Operations on the Antrum of Highmore, with Presentation of a Patient, *Laryngoscope* **19** 904-910, 1909

5 Canfield, R. B. The Submucous Resection of the Lateral Nasal Wall in Chronic Empyema of the Antrum, Ethmoid and Sphenoid, *J. A. M. A* **51** 1136-1141 (Oct 3) 1908

6 Hirsch, O. *Wien med Wchnschr* **58** 1550-1554 (July 4) 1908

7 Sewall, E. C. Diagnosis and Treatment of Chronic Maxillary Sinus Infection, *Arch Otolaryng* **8** 405-419 (Oct) 1928

8 Hilding, A. C. Experimental Sinus Surgery. Effects of Operative Windows on Normal Sinuses, *Ann Otol, Rhin & Laryng* **50** 379-392 (June) 1941

9 Proetz, A. W. Essays on the Applied Physiology of the Nose, St. Louis, Annals Publishing Company, 1941, p. 356

10 Zuckerkindl, E. Normale und pathologische Anatomie der Nasenhöhle und ihrer pneumatischen Anhangs, Leipzig, W. Braumüller, 1893

11 Siebenmann, F. Beitrag zur Lehre von der Entstehung und Heilung kombinierter Nebenhöhlenentzündungen der Nase, *Monatschr f. Ohrenh* **46** 656-661, 1912

in 1889 and stated that he was able to clean the edematous membranes from the antrums. The latter statement I doubt.

Onodi<sup>12</sup> dilated the ostium with the aid of a trocar.

Bayer<sup>13</sup> removed the pars membranacea with a galvanocautery.

Kubo<sup>14</sup> used that procedure and stated that the window stayed open and that the patients were taught to irrigate their own sinus through this opening.

About ten years ago a member of the department of otolaryngology of Washington University operated on 5 patients, making a window through the middle meatus and doing no other surgical work. The end results were reported as being excellent.

Hajek<sup>15</sup> was satisfied with the results which he obtained with middle meatal windows.

#### QUESTIONNAIRE

In order to obtain accurate statistical data from rhinologists, the following questionnaire was mailed to each member of the Triological Society.

- 1 Have you ever made a permanent opening into the antrum through the middle meatus?
- 2 Diagnosis?
- 3 Approximate number of cases?
- 4 Approximately when did you do this the first time?
- 5 What was the age group?
- 6 Technic employed?
- 7 Have these patients had any stasis of antral secretion?
- 8 Have you made any subsequent roentgenograms? If so, what did they reveal?
- 9 End results?
- 10 May I quote you?

Four hundred and ninety-one copies of this were sent, and 366 replies were received. Two hundred and thirty-six physicians stated that they had never performed that operation. Several went further and stated that they were opposed to any traumatizing of the tissues within the middle meatus. Ninety-four stated that they had performed fenestration of the antrum through the middle meatus. (Their reports are summarized in table 1.) In addition to the 94 who reported cases,

12 Onodi, A. Die Eröffnung der Kieferhöhle im mittleren Nasengange, *Arch f Laryng u Rhin* **14** 154-160, 1903.

13 Bayer, C. Beitrag zum Studium und zur Behandlung des Empyems der Highmoreshöhle, *Deutsche med Wchnschr* **15** 187-190, 1889.

14 Kubo, I. Ueber die supratubinale Eröffnung bei der Sinusitis maxillaris chronica, *Arch f Laryng u Rhin* **26** 351-356, 1912.

15 Hajek, M. Pathology and Treatment of the Inflammatory Diseases of the Nasal Accessory Sinuses, translated by J. D. Heitger and F. Hansel, ed 5, St Louis, C. V. Mosby Company, 1926, vol 1.

other men stated that they had performed the operation, but they gave such meager information that the reports of results were of no scientific value

Forty additional members of the Triological Society reported that they had made an antral window through the middle meatus either with or without a window in the inferior meatus when doing a radical operation on the maxillary sinus. According to those reports, 97 per cent of their patients received a better than average result

TABLE 1—*Summary of Data Supplied by Members of the Triological Society in Reply to a Questionnaire*

Physicians quoted	94
Year of earliest reported antral window made through middle meatus	1902
Cases reported, some bilateral	1,376
Age range	?
Maxillary sinusitis	
Acute	250
Subacute	212
Chronic	885
Technic	
Electrocoagulation	5
Punch	596
Rasp	4
Combination of punch and rasp	512
Postoperative retention of secretion	
Definite stasis	77
Little stasis	326
No stasis	597
Postoperative roentgen observations	
Thickened membrane	300
Slight clouding	36
Clouding	5
Clear	76
End result	
Excellent	118
Good	641
Fair	244
Poor	69

#### ANATOMY

Since the anatomy of the maxillary sinuses, together with that of the anomalies, has been thoroughly described many times in the literature, I shall limit my discussion to a few of the important facts

The maxillary sinus opens on the floor or the lateral wall of the infundibulum posteriorly. The ostium may be merely an opening but is usually a passage simulating a tubule several millimeters in length. The nasal end of this tubule may be horizontal, vertical or oblique. The tubule usually takes a downward and outward course between the bulla and the uncinate process of the ethmoid bone to open into the maxillary sinus. The tubule varies greatly in length, direction and shape. Though its general direction is downward and outward, it may be horizontal or vertical or a combination of the four directions. Neither

its length nor its diameter is constant, as shown by the fact that various authors have observed different dimensions in the series of skulls which they have studied

Zuckerlandl<sup>10</sup> stated that in studying 300 specimens he found the largest ostium to be 19 by 5 mm and the smallest to be 3 mm in diameter Schaeffer,<sup>16</sup> in examining 122 specimens found the tubule to vary in diameter from 1 to 6 mm and in length from 1 to 22 mm Myerson<sup>17</sup> stated that in the sinuses which he studied the diameter of the tubule varied from 1 mm to 13 by 11 mm However, the average diameter of the ostium in the average specimen is less than 5 mm



Fig 1—The nasal surface of the left superior maxilla *A* indicates the ascending process, *B*, the anterior nasal spine, *C*, the lacrimal groove, *D*, the hiatus maxillaris

The accessory ostium is merely an opening in the pars membranacea, located in the posterior portion of this anatomic entity It probably occurs in 30 to 40 per cent of the specimens It varies in size but is usually much smaller than the normal ostium

16 Schaeffer, J P The Nose, Paranasal Sinuses, Nasolacrimal Passageways, and Olfactory Organ in Man A Genetic, Developmental, and Anatomico-Physiological Consideration, Philadelphia, P Blakiston's Son & Co, 1920

17 Myerson, M C The Natural Orifice of the Maxillary Sinus Anatomic Studies Arch Otolaryng 15 80-91 (Jan) 1932



Fig 2—The nasal surface of the left superior maxilla, showing the palate bone and the maxillary process of the turbinal bone filling in a portion of the hiatus maxillaris. *A* indicates the ascending process, *E*, the lacrimal bone, *F*, the lacrimal, *D*, the hiatus maxillaris, *G*, the attachment of the turbinal bone, *H*, the body of the maxilla forming part of the floor of the ethmoid sinus, *I*, the sphenopalatine foramen, *J*, the perpendicular plate of the palate bone, *K*, the maxillary process of the turbinate bone (outlined for clarity).

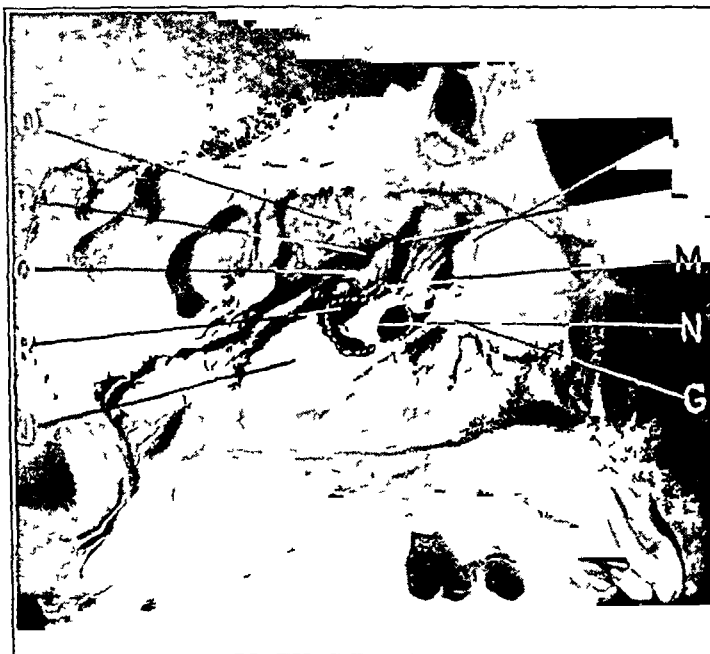


Fig 3—Structure of the lateral nasal wall, showing the hiatus maxillaris further filled in by the bulla and the uncinate process of the ethmoid bone. The middle turbinate has been cut away at its attachment. A dotted line shows the area excised in the middle meatus window operation. *O* indicates the ethmoid labyrinth, *P*, the attachment of the middle turbinate, *Q*, the bulla, *R*, the pars membranacea, *J*, the perpendicular plate of the palate bone, *F*, the lacrimal canal, *L*, the hiatus semilunaris, *M*, the ostium of the maxillary sinus, *N*, the uncinate process, *G*, the attachment of the turbinate bone.

The tissues around the ostium are loose and cavernous in type, similar to those around the turbinate bone

#### SURGICAL ANATOMY

The pars membranacea is bounded above by the horizontal plate of the maxilla, below by the superior portion of the inferior turbinate bone, anteriorly by the uncinate process and the lacrimal bone and posteriorly by the palate bone

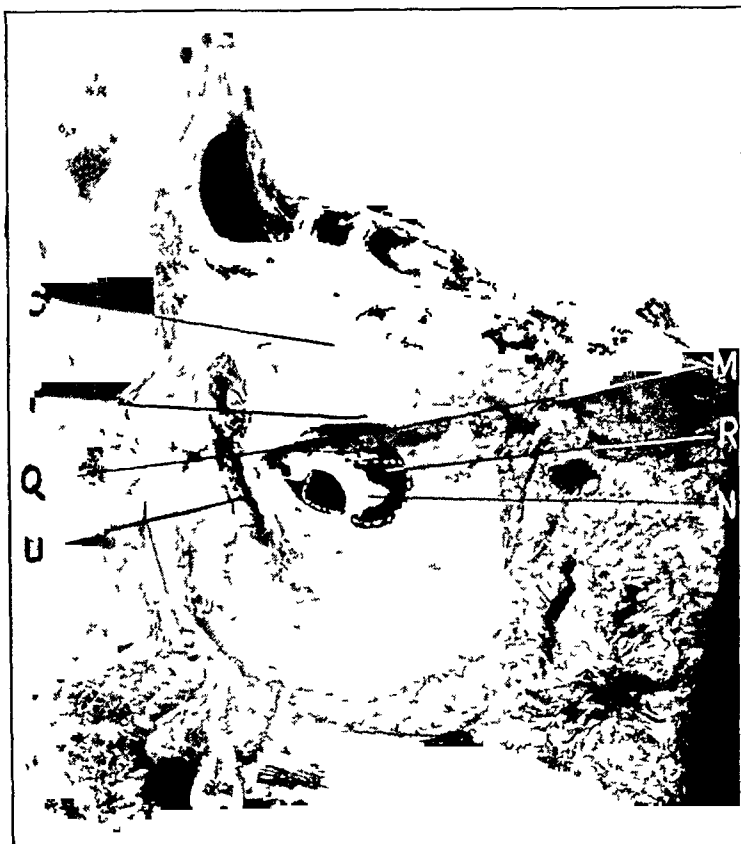


Fig 4—Section showing the lateral surface of the nasal wall of the left antrum. The dotted line shows the area excised in the middle meatus window operation. S indicates the lamina papyracea, T, the orbital plate of the superior maxilla, Q, the bulla, U, the nasolacrimal duct, M, the ostium of the maxillary sinus, R, the pars membranacea (cut away), N, the uncinate process.

The ostium is located in the superior portion of the pars membranacea. It is therefore necessary in making a middle meatal window to make it from the ostium downward. The vessels and the nerves which enter the antrum in the region of the ostium are not located within a radius of 1 cm of the ostium itself. Hence a window might be made in this area without damaging these vital structures. In studying a series of 18 specimens it was found that the average size of the pars membranacea was 7 by 16 mm. Vertically this membrane varies from

5 to 10 mm, while anteroposteriorly it varies from 12 to 28 mm. The maxillary ostium was found to be from 8 to 17 mm from the lacrimal canal. It is important to note that while the average distance from the maxillary ostium to the lacrimal canal is 10 mm, the lacrimal canal is only 5 mm from the anterior border of the pars membranacea. Therefore, in making a middle meatal window the tissues removed should be

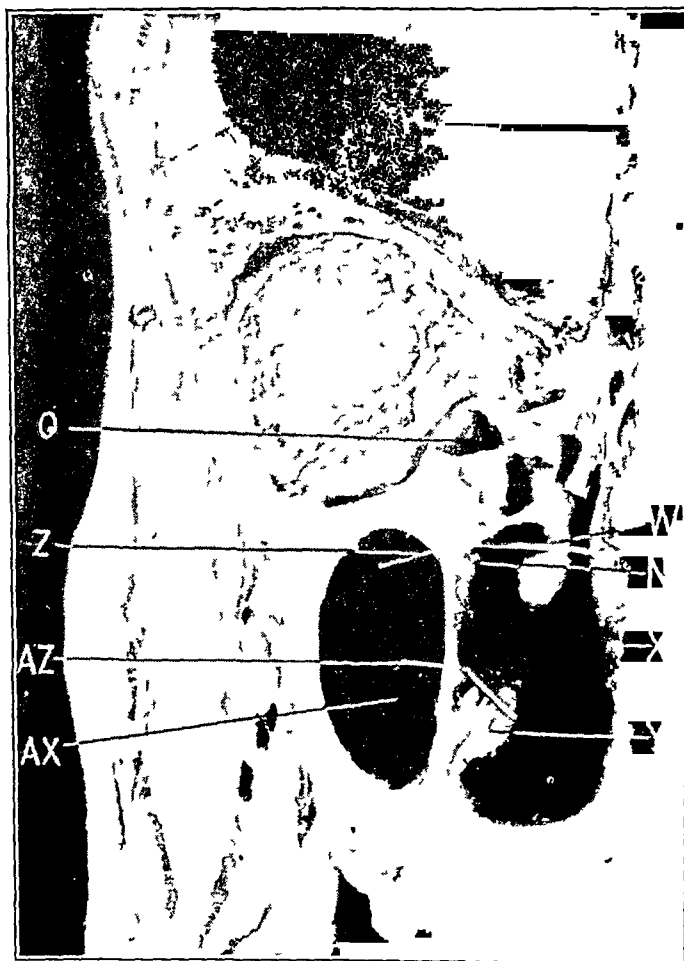


Fig 5—Frontal section cut just behind an accessory ostium. *O* indicates the ethmoid labyrinth, *Z*, a straw in the ostium, *AZ*, a straw in an accessory ostium, *AX*, the maxillary sinus, *W*, the middle turbinate, *N*, the uncinate process, *λ*, the septum, *Y*, the inferior turbinate.

inferior and posterior to the ostium. While the distance from the posterior edge of the pars membranacea to the posterior palatine canal was not accurately measured in the work for this thesis, its average distance is approximately 1 cm. Therefore, one need not be concerned with this structure and its contents in making a middle meatal window.

## PHYSIOLOGY

The physiology of the drainage of the maxillary sinus shows that drainage is established by ciliary action and not by gravity The cilia

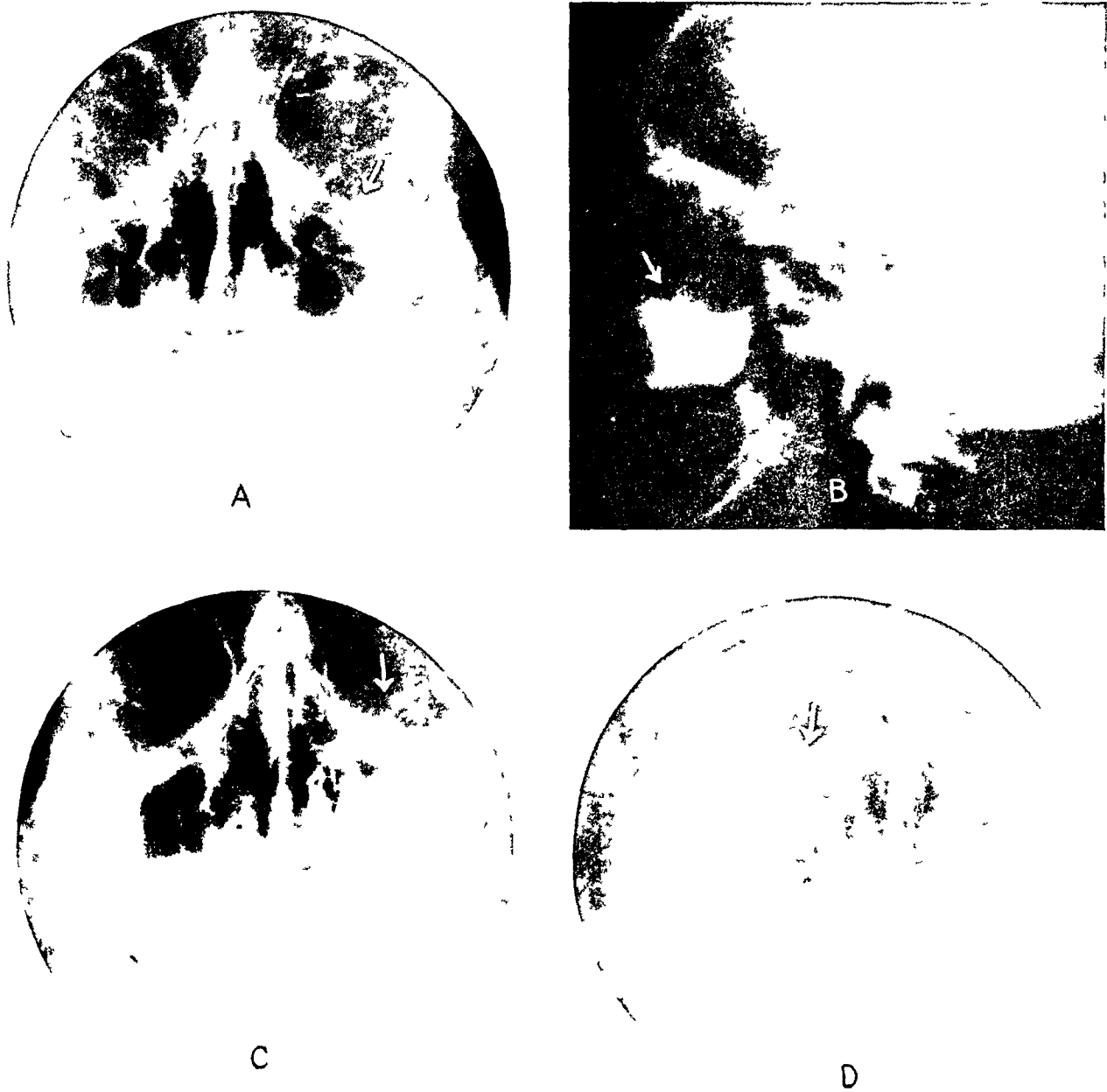


Fig 6 (case 2)—*A*, preoperative roentgenogram showing increased density along the lateral walls of the antrums *B*, lateral view after injection of iodized oil, showing no filling defect of the right antrum *C*, frontal view, showing no filling defect The antrum was treated by the middle meatus window operation *D*, roentgenogram taken six and one-half months after operation It shows increased density of the right antrum No improvement was shown by the roentgen examination

are slender motile rods and are situated close together on the surface of the epithelium The free end of each cilium is thicker than that por-



tion which penetrates into the columnar epithelium, the lining membrane. The cilia beat in concert, they rest for a short time, and then resume their work. The effective stroke is in one direction only. It has been

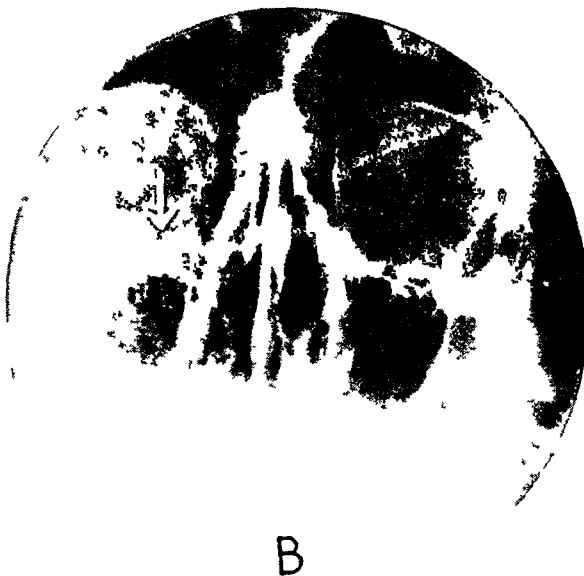
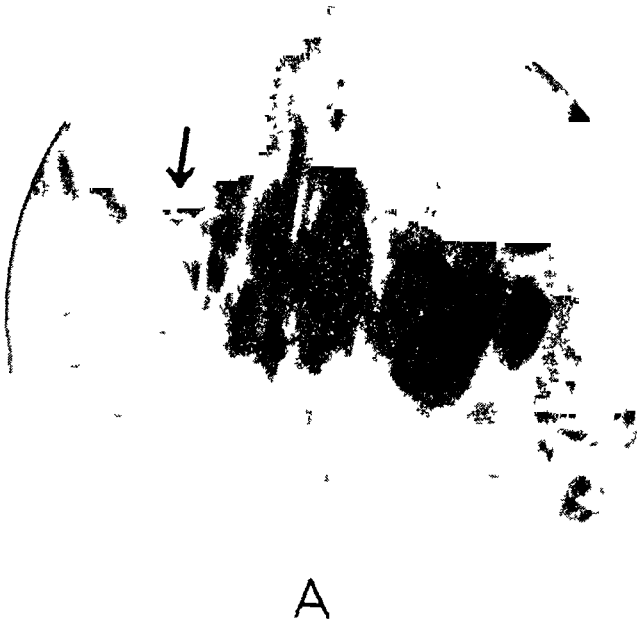


Fig 7 (case 3) —*A*, preoperative roentgenogram showing increased density of the left antrum. The left antrum was treated by the middle meatus window operation. *B*, roentgenogram taken six and one-half months after operation. The left antrum reveals slightly increased density. Improvement is noted.



Fig 8 (case 4)—*A*, preoperative roentgenogram showing increased density of right antrum *B*, roentgenogram made after injection of iodized oil, showing a large filling defect of the right antrum The antrum was treated by the middle meatus window operation *C*, roentgenogram made eight months after operation There is little increase of density in the right antrum Improvement is noted

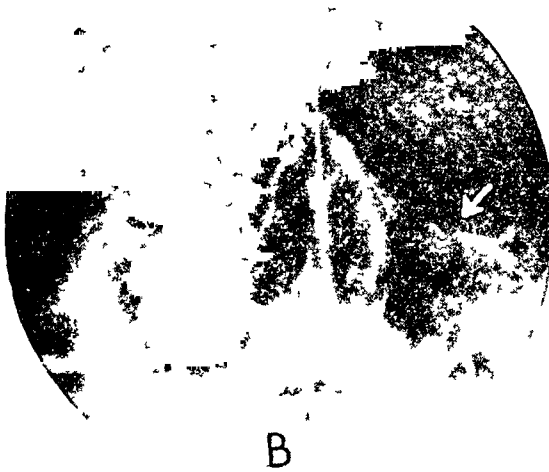


Fig 9 (case 5)—*A*, preoperative roentgenogram showing increased density of the right antrum. The antrum was treated by the middle meatus window operation. *B*, roentgenogram made seven months after operation. The right antrum is slightly cloudy. Improvement is noted.

stated that the cilia will empty a maxillary sinus within a few hours if the substance is of low viscosity

Hilding,<sup>18</sup> using india ink in his experiments, reported on the course of the currents in the frontal sinus of a dog. These currents proceeded in



A



B



C



D

Fig 10 (case 6)—*A*, preoperative roentgenogram showing increased density of the antrums. *B* and *C*, roentgenograms made after injection of iodized oil, showing no filling defect of the right antrum. The antrum was treated by the middle meatus window operation. *D*, roentgenogram made ten months after operation. It shows no increase in the density of the right antrum. Improvement is noted.

<sup>18</sup> Hilding, A. C. The Influence of Ciliary Activity on the Bacteriology of the Nose. Direction of Ciliary Currents in the Frontal Sinus of a Dog, Proc Staff Meet, Mayo Clin 6:320-322 (May 27) 1931.

a straight line from the deepest portion of the frontal sinus, and from the other portions of the frontal sinus the currents proceeded in a slightly curved course of the ostium. He stated that the rate of flow

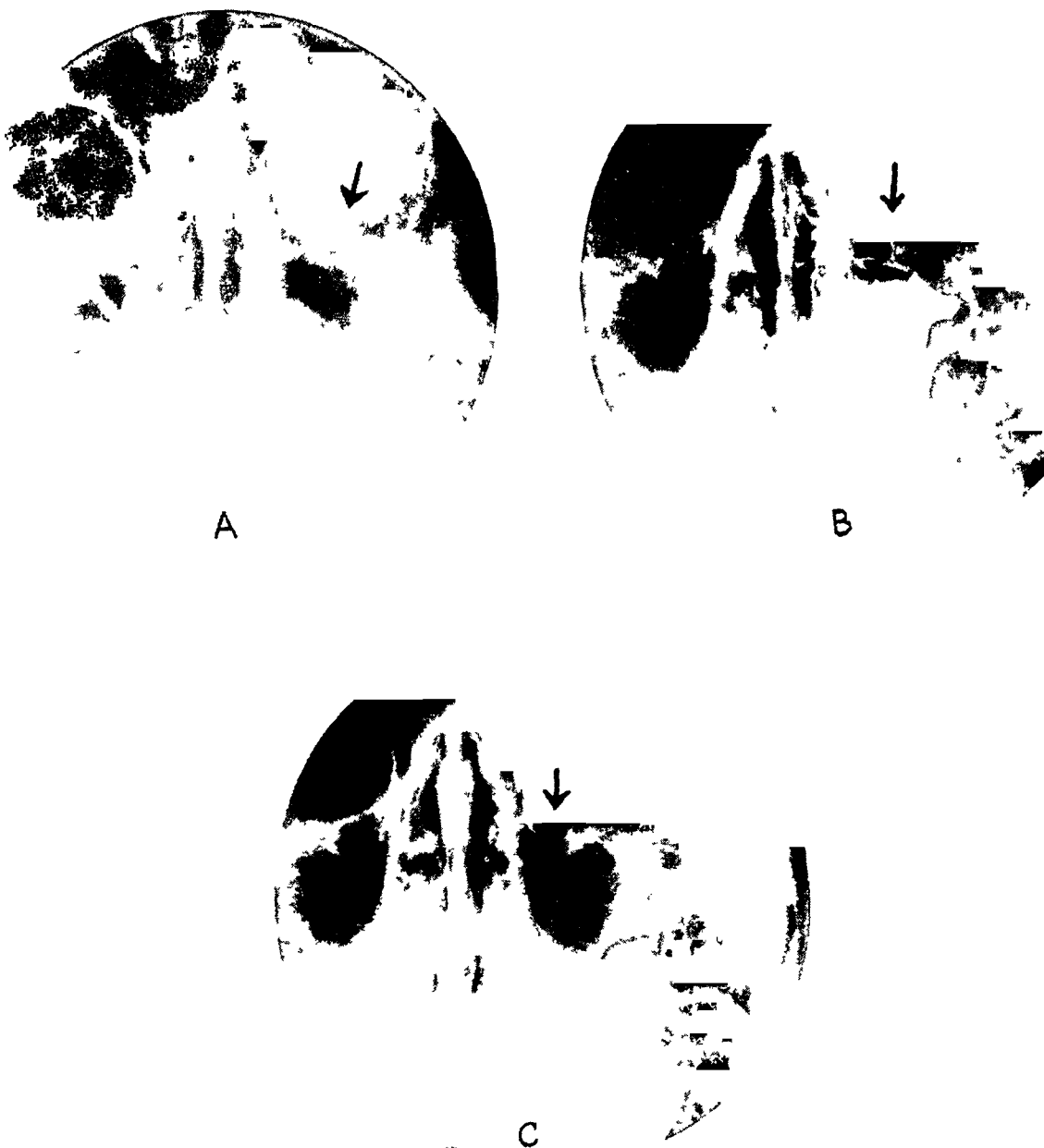


Fig 11 (case 7) —*A*, preoperative roentgenogram showing increased density of the right antrum. *B*, roentgenogram made after injection of iodized oil. Note the filling defect of the right antrum. The antrum was treated by the middle meatus window operation. *C*, roentgenogram made seven months after operation. It shows an apparently normal right antrum.

varied between 2 and 8 mm per second, the greater speed being attained as the ostium was approached.

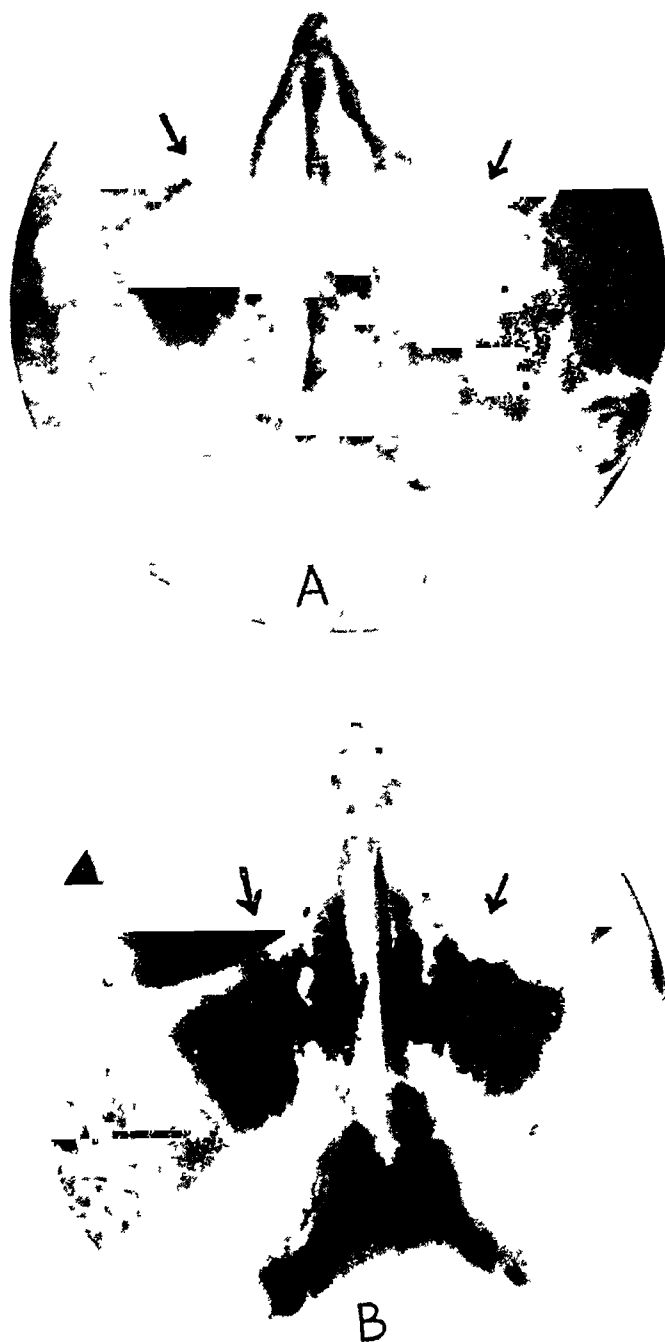


Fig 12 (cases 8 and 9)—*A*, preoperative roentgenogram showing little increase of density of the antrums. Each antrum was treated by the middle meatus window operation. *B*, roentgenogram taken six months postoperatively. The antrums appear normal. These roentgenograms photographed poorly.

Proetz,<sup>19</sup> in experimenting with ciliary action, found that particles would go around any obstruction placed in their path. He further noted that a window opened in the antrum through the inferior meatus caused the particles to be carried around the opening to the ostium.

Lucas,<sup>20</sup> experimenting on ciliary action in the maxillary sinus of the rhesus monkey, observed that the particles were propelled in a spiral route toward the ostium. He felt that this increased the capacity of the cilia for moving larger amounts of material.

Normally the mucus lies against the membrane as a very thin coat and moves constantly toward the ostium. When the ostium is blocked and the cilia cease to function, the mucus tends, presumably by gravity, to flow downward.

Hilding<sup>21</sup> has shown that little air is exchanged between the nose and the antrums by way of the ostiums. He stated that in hyper-ventilation most of the exposed epithelium became thickened, lost its cilia and assumed the characteristics of stratified squamous epithelium. The lining membrane thickened, and the number of glands increased. The nasal mucosae of the open nares of a dog and a rabbit were found to react entirely differently.

After the antral ostium becomes closed, the absorption of the air that is within the antrum creates a partial vacuum, which produces congestion and edema, and transudation of the fluid follows. The tissues around the ostium are more susceptible to outside influences than the lining membrane of any other portion of the antrum. Therefore, the ostium tends to become swollen, in consequence of the swelling the exchange of air is prevented and the ciliary action stopped before the lining membrane of the remainder of the antrum is involved. To maintain a healthy antrum the ostium must be patent.

#### PRESENTATION OF CASES

Thirty-two patients were operated on for chronic or subacute maxillary sinusitis, although several other sinuses were infected, as was proved clinically and roentgenologically. The ages of the patients whose cases are reported ranged from 16 to 59, the average being 31½ years. There were 17 females and 15 males.

Of the 30 patients, only 11 returned for the final examination despite constant urging and pleading. (Thirteen cases are reported, as 2 patients were operated on bilaterally.) The patients who refused to return stated that they were having no trouble and were feeling fine.

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19 Proetz, A. W. *The Displacement Method of Sinus Diagnosis and Treatment. A Practical Guide to the Use of Radiopaques in the Nasal Sinuses*, St. Louis, Annals Publishing Company, 1931.

20 Lucas, A. M. *The Nasal Cavity and Direction of Fluid by Ciliary Activity in Macacus Rhesus (Desm.)*, *Am J Anat* **50** 141-177 (March) 1932.

21 Hilding, A. C. *Experimental Surgery of the Nose and Sinuses. Changes in Morphology of the Epithelium Following Variations in Ventilation*, *Arch Otolaryng* **16** 9-18 (July) 1932.

It is interesting to note that in 1 case the patient when first seen had in addition to sinusitis a complete congenital bony occlusion of the posterior choanae. The occluding wall was removed before the antral window was made.

The patients were examined prior to or during the course of treatment and were found to be in good health generally. The serologic examinations gave negative results.

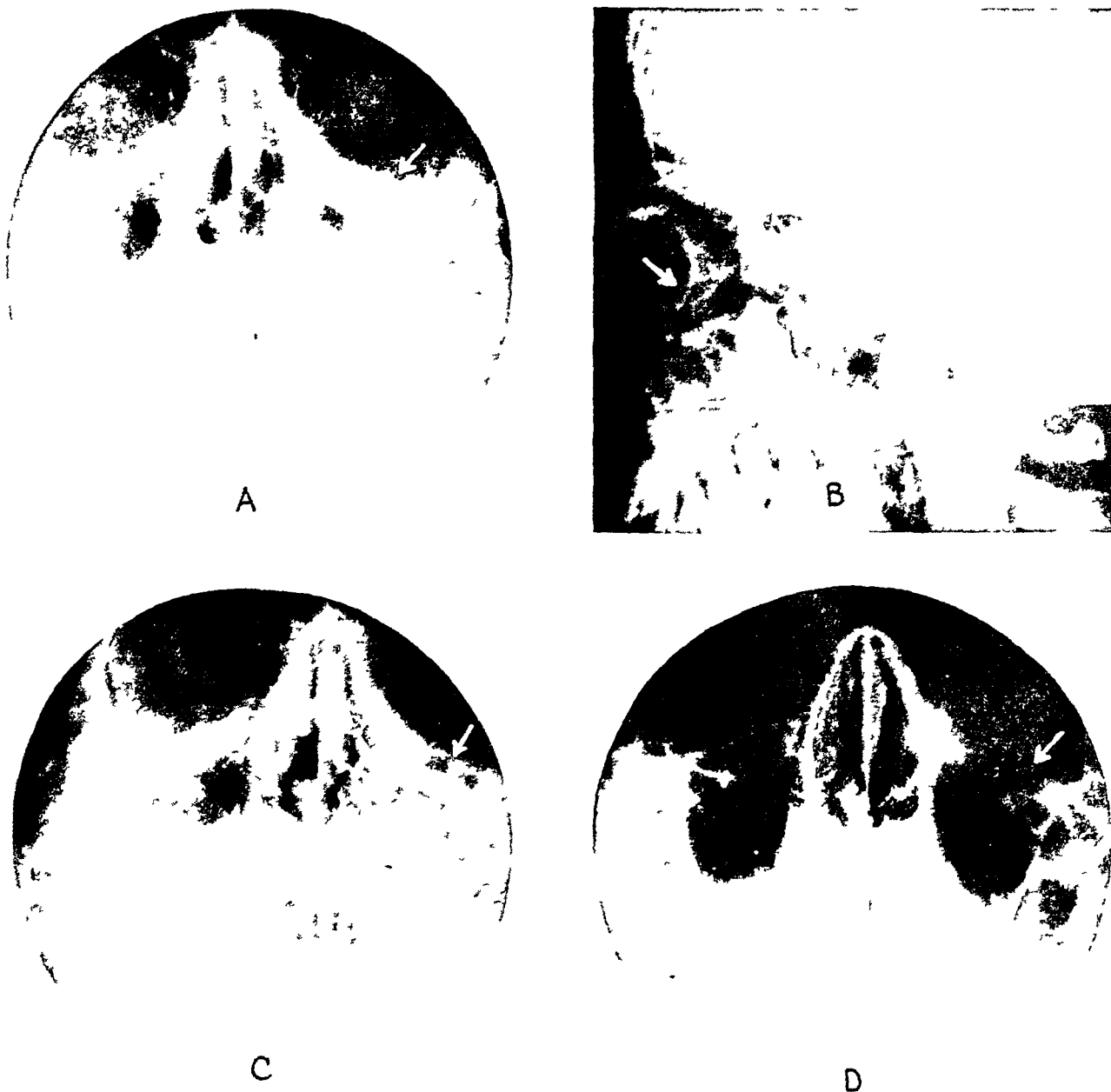


Fig 13 (case 10)—A, preoperative roentgenogram showing little increase of density of the antra, more marked on the right. B and C, preoperative roentgenograms made after injection of iodized oil. Note the large filling defect of the right antrum. The right antrum was treated by the middle meatus window operation. D, roentgenogram made nine months after operation. The right antrum appears normal.



## PROCEDURE OF EXAMINATION

The patient is examined to obtain information on the following points

- 1 History and age
- 2 Type of discharge, if present
- 3 Gross pathologic changes of nasal mucous membrane
- 4 Appearance of nasopharynx as viewed with
  - (a) Mirror
  - (b) Nasopharyngoscope
- 5 Interpretation of roentgenograms
- 6 Size and shape of antrum as shown by the roentgenograms
- 7 Type of naris
- 8 Position of middle turbinate bone
  - (a) Crowded against the lateral wall
  - (b) Normal position
  - (c) Protruding toward the nasal septum
- 9 Deviations of nasal septum
- 10 Appearance of middle meatus as viewed with nasopharyngoscope
- 11 Clinical evidence of an allergic reaction
- 12 Smears for eosinophils
- 13 Return on irrigation of antrum
- 14 Cultures made of antral washings
- 15 Interpretation of roentgenogram made after injection of iodized poppyseed oil 40 per cent

## SURGICAL PROCEDURE

With cocaine mud being used to produce anesthesia, the natural ostium was located, when possible, with a curved olive-tipped probe. The distance from the ostium to the ala was then measured.

A Myles punch, rather triangular in shape, was introduced into the middle meatus by using the aforementioned measurement, the tissues covering the middle turbinate bone being pushed aside as needed.

The male blade was opened and was introduced into the antrum through the pars membranacea. This was done by forcing the blade through these tissues.

An opening approximately 5 by 8 mm was made in each case. In some instances this required using the punch two or three times.

An attempt was made to remove the normal ostium in each case. However when the ostium could not be located, an opening was made in that region.

During the operation the patients complained of little if any pain. Practically no bleeding occurred. The surgical work was performed rapidly, and the procedure in each case was simple. No rasping was done, and, with the use of a cleancutting punch, all edges were left smooth and even.

Trauma of the intranasal structures was avoided as much as possible. In no case was the middle turbinate structure partially or completely removed, and the other turbinate structures were not disturbed.

## FINAL EXAMINATION

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Following the surgical procedure, a minimum period of six months was allowed to elapse before the patient was examined in order that the effect on the antrum and the adjacent structures might be accurately determined. The patient's history of any nasal disturbances experienced during the interim was taken. The naris and the nasopharynx were examined for discharge, discoloration, thickening of the tissues and growth of lymphoid tissue.



A



B

Fig 14 (case 11)—*A*, preoperative roentgenogram showing left maxillary sinus markedly cloudy. The sinus was treated by the middle meatus window operation. *B*, roentgenogram made nine months after operation. The left antrum appears normal.



Fig 15 (cases 12 and 13) —*A*, preoperative roentgenogram showing increased density of both antrums. Each antrum was treated by the middle meatus window operation. *B*, roentgenogram made seven months after operation. It shows the antrums cloudy. No improvement is noted in the left antrum, much improvement in the right.

The inferior meatus was anesthetized with butacaine sulfate U S P (butyn sulfate®) care being taken that none of the solution reached any other portion of the nares

In introducing the trocar and cannula into the antrum an attempt was made to place them so that the distal end would lie just beneath the operative window

Through the cannula a nasopharyngoscope was passed. It was possible to obtain a satisfactory view of the lower edge of the window, of the lining membrane just below the window and of the lower edges of the posterior and anterior portion of the window in each case. In a few cases the superior part of the window was visible, but in most instances the distance from the nasopharyngoscope was too great for a detailed examination

In all the cases except nos 1 and 3, the lining membrane was normal below the window, and neither granulation tissue nor scarring nor abscess formation was noted in any visible area of any of the antrums. The foregoing statement was true of the case in which the window had closed

In cases 1 and 3, though the lining membrane appeared normal elsewhere, some thickening was discerned just below the window. This thickening was not due to granulation or fibrous tissue but apparently was due to edema

The ideal postoperative examination would have consisted of opening each antrum through the canine fossa and taking a section of tissue from just below the antral window for biopsy. This was impossible, hence, with this limitation, one utilized the nasopharyngoscope

Immediately after the aforementioned examination and with the cannula still in place, 02 cc of india ink was injected into the antrum. When the cannula was removed, the inferior meatus was tightly packed with cotton to prevent any possible leakage. The patient's head was kept erect and the middle meatus observed in order to ascertain when and if the india ink appeared by ciliary activity in the normal manner

Subsequent to this observation and after anesthesia had been produced, the window was examined with a probe for patency and any abnormality of the surrounding tissue. The antrum was then irrigated with isotonic sodium chloride solution, after which the middle meatus was examined with a nasopharyngoscope. A roentgen examination was made<sup>22</sup>. If the interpretation of the roentgenograms was unsatisfactory, iodized poppyseed oil 40 per cent was injected into the antrum and additional roentgenograms were made

As the time required to eliminate iodized oil from an antrum is such a variable factor, as shown in many cases not connected with this experimental work, it was decided not to confuse the final results by routinely injecting iodized oil and observing by roentgen examinations whether it was eliminated from the antrum both by ciliary action and by gravity

Table 2 gives a detailed report of each case from the first through the final examination

PATHOLOGIST'S REPORT MADE ON MICROSCOPIC EXAMINATION OF TISSUE  
REMOVED FROM THE MIDDLE MEATUS WHILE THE ANTRAL WINDOW  
WAS BEING MADE

CASE 1 (J D) —There are superficial areas of necrosis with exudative and acute purulent inflammation. This inflammation is present on a surface lined

<sup>22</sup> The roentgenograms taken in case 1 are not shown because it was impossible to obtain the first plates from the roentgenologist. It would be unfair and noninformative to show only the end results

TABLE 2—Summary of Data on Twelve Patients in Whom an Antral Window

Case	Patient	Race	Sex	Age	Diagnosis	History	Nasal Discharge	Gross Pathologic Condition of Nasal Mucous Membrane
1	J D	White	M	40	Chronic right maxillary sinusitis	Pain over right cheek for 1 wk many previous attacks	Purulent	Congestion
2	O M B	White	F	40	Bilateral chronic maxillary sinusitis	Pain on right side of face, nasal blockage, discharge 1 yr	Purulent	Marked congestion
3	N G	White	F	23	Subacute left maxillary sinusitis	Severe pain over right cheek 2 days, previous attacks	Purulent	Marked congestion
4	C G B	White	M	59	Chronic pansinusitis	Nasal blockage, headaches and discharge many years	Mucoserous	Congestion polypi in right naris
5	A L N	White	F	14	Complete bony occlusion of postchoanae, chronic right ethmoid and maxillary sinusitis	Complete nasal blockage, headaches and discharge since infancy	Mucopurulent	Congestion
6	L W	White	F	34	Chronic right maxillary sinusitis	Blockage of ears, nasal discharge, frequency of coryza 5 yr	Purulent	Congestion
7	A J W	White	F	16	Subacute pansinusitis	Headaches, nasal blockage, pain over right cheek 6 mo	Purulent	Definite congestion
8	F P *	White	F	35	Bilateral chronic maxillary sinusitis	Headaches, nasal blockage, frequency of coryza 2 yr	No discharge	Slight congestion
9	F P *	White	F	35	Bilateral chronic maxillary sinusitis	Headaches, nasal blockage, frequent coryza 2 yr	No discharge	Moderate congestion
10	N C	White	M	21	Bilateral subacute maxillary sinusitis	Nasal discharge with blockage, headaches 1 mo	Purulent	Congestion and edema
11	E E T	White	F	29	Left maxillary and ethmoid sinusitis	Attacks for 1 yr with pain, nasal discharge and blockage	Purulent	Congestion
12	V M B *	White	F	44	Bilateral chronic maxillary and ethmoid sinusitis	Attacks for 2 yr with headaches, nasal discharge and blockage	Purulent	Marked congestion
13	V M B *	White	F	44	Bilateral chronic maxillary and ethmoid sinusitis	Attacks for 2 yr with headaches, nasal discharge and blockage	Purulent	Marked congestion

\* Patients 8 and 9 are the same person patients 12 and 13 are the same person 1 e 1 patient operated on bilaterally is reported as 2 patients

*Was Made in the Middle Meatus Without Additional Surgical Procedures*

Gross Pathologic Condition of Nasopharynx	Interpretation of Roentgenogram	Size and Shape of Antrum	Naris	Position of Middle Turbinate Bone	Position of Nasal Septum	Condition of Middle Meatus as Viewed with Nasopharyngoscope	Clinical Evidence of Nasal Allergy
Moderate congestion, lymphoid nodules swollen	Right maxillary sinusitis	Large and round type	Crowded	Close to lateral wall	Midline	Edema and congestion, ostium not seen	None
Congestion purulent secretion	Bilateral maxillary and sphenoid sinusitis	Small, triangular	Crowded	Ample room for drainage	Deviated to the left	Thickening and congestion of mucous membrane, ostium not seen	None
Small mass of adenoid tissue, congestion	Left maxillary sinusitis	Large and round	Open	Adjacent to lateral wall	Deviated to the left	Pus seen coming from ostium, edema	None
Lymphoid nodules swollen, congestion and discharge	Bilateral ethmoid and maxillary sinusitis	Large and triangular	Crowded	Adjacent to lateral wall	Markedly deviated to the right	Little congestion, some edema, small polyp seen in ostium	Polyp
Dry and pale, no lymphoid nodules noted	Marked cloudiness of right maxillary sinus	Large and square	Very crowded	Adjacent to lateral wall	Midline	Swelling and congestion, ostium very small	None
Lymphoid nodules swollen, mucous membrane thickened and congested	Bilateral cloudiness of antrums	Small and triangular	Open	Normal	Midline	Swelling and congestion, infundibulum a tiny groove, ostium not seen	None
Adenoid tissue, mucous membrane thickened and congested	Maxillary sinuses cloudy, ethmoid sinuses slightly cloudy, sphenoid sinus suggests involvement	Medium size, round triangular	Crowded	Adjacent to lateral wall	Deviated to the left	Ostium pinpoint in size, much congestion	None
Small mass of adenoid tissue	Maxillary sinuses cloudy	Large and square	Crowded	Room for drainage	Deviated bilaterally	No congestion, ostium noted	None
Small mass of adenoid tissue	Maxillary sinuses cloudy	Large and square	Open	Room for drainage	Deviated bilaterally	Moderate congestion, ostium not seen	None
Lymphoid nodules swollen, congestion	Maxillary and ethmoid sinuses cloudy	Large and triangular	Open	Adjacent to lateral wall	Deviated to the left	Pus coming from ostium, swelling and congestion	None
Adenoid tissue, lymphoid nodules swollen and congested	Left maxillary and both ethmoid sinuses cloudy	Small and triangular	Crowded	Adjacent to lateral wall	Deviated to the left	Pus present, small polyp, congestion, ostium not seen	None
Lymphoid nodules swollen, congestion	Maxillary and ethmoid sinuses cloudy bilaterally	Medium size, round	Open	Room for drainage	Midline	Pus present congestion	None
Lymphoid nodules swollen, congestion	Maxillary sinuses quite cloudy, ethmoid sinuses cloudy	Medium size, round	Open	Room for drainage	Midline	Pus present, congestion	None

No eosinophilic leukocytes were found in the smears of any of the cases

TABLE 2—Summary of Data on Twelve Patients in Whom an Antral Window Was

Case	Patient	Result of Antral Irrigation *	Bacteria Isolated from Antrum	Interpretation of Roentgenograms of Antrum Made After Injection of Iodized Oil †	Date and Side of Middle Meatal Resection	Interim (Months) Between Operation and Final Examination	History of Nasal Condition Since Operation	Nasal Discharge	Appearance of Nasal Mucous Membrane
1	J D	Pus	Staph aureus		12/ 4/44 Right	11	Has had only slight discharge, no other complaints	Mucoid	Slightly congested
2	O M B	Pus	Str hemo lyticus	No filling defect of either antrum	10/16/45 Right	6½	Drainage and head aches at times	None	Normal
3	N G	Pus	Pneumococcus		4/ 5/45 Left	6½	Headaches occasionally, condition improved	Mucoid	Moderately congested
4	C G B	Return clear	Str hemo lyticus	Large filling defect of right antrum	12/ 7/45 Right	8	Occasional attacks of sinusitis, condition much improved	None	Congested
5	A L N	Pus	Str hemo lyticus		5/ 7/45 Right	7	No complaints	None	Slightly congested
6	L W	Pus	Staph albus and Friedlander's bacillus	No filling defect	11/ 2/44 Right	10	No complaints	None	Normal
7	A J W	Return clear	Staph aureus	Moderate sized filling defect	3/ 5/45 Right	7	Only occasional nasal blockage	None	Normal
8	F P	Return clear	Str hemo lyticus		10/25/45 Right	6	Occasional headache	None	Normal
9	F P §	Pus	Str hemo lyticus and pneumococcus		10/ 5/45 Left	6	Occasional headache	None	Normal
10	N C §	Pus	Pneumococcus	Large filling defect	12/ 4/44 Right	9	No complaints	None	Slightly congested
11	E E T	Pus	Staph hemo lyticus		12/ 4/44 Left	9	No complaints	None	Normal
12	V M B §	Pus	Streptococcus, unidentified	Moderate filling defect	3/ 4/46 Right	7	No complaints	None	Normal
13	V M B §	Pus	Streptococcus, unidentified	Moderate filling defect	3/ 4/46 Left	7	No complaints	None	Normal

\* This and the following columns are to be considered as continuations of the first half of the table of the preceding pages. The case numbers have been repeated for the convenience of the reader.

† Roentgenograms were made after injection of iodized oil only in cases in which additional information was desired.

§ Patients 8 and 9 are the same person, patients 12 and 13 are the same person. I.e., a patient operated on bilaterally is reported as 2 patients.

Appearance of Middle Meatus as Viewed with Nasopharyngoscope	Appearance of Nasopharynx	Appearance of Lining Membrane of Antrum as Viewed with Nasopharyngoscope	Interim (Minutes) Between Introduction and Reappearance of India Ink	Patency of Window	Condition of Middle Meatus as Examined with Probe	Result of Antral Irrigation	Interpretation of Roentgenogram
Slightly congested, margins of window healed	Few swollen lymphoid nodules present	Moderately congested, some thickening of lining membrane just inferior to window	33	No contraction	Normal	Return clear	Right antrum moderately cloudy
Not congested, margins of window healed	Normal	Normal	21	No contraction	Normal	Return clear	Right antrum slightly cloudy
Somewhat congested, margins of window healed	Congested	Lower edge of window thickened, this area congested	24	No contraction	Normal	Return clear	Left antrum cloudy
Somewhat congested, window closed, ostium not seen	Congested	Normal, no window seen	29	Closed	Normal	Return clear†	Right antrum moderately cloudy
Normal, margins of wound healed	Normal	Normal	32	No contraction	Normal	Return clear	Right antrum slightly cloudy
Congested, margins of wound healed	Normal	Normal but congested	31	No contraction	Normal	Return clear	Right antrum normal
Normal, margins of wound healed	Normal	Normal	22	No contraction	Normal	Return clear	Right antrum normal
Slightly congested, margins of window healed	Slightly congested	Normal	19	No contraction	Normal	Return clear	Right antrum normal
Normal, margins of wound healed	Slightly congested	Normal	21	No contraction	Normal	Return clear	Left antrum normal
Somewhat congested, margins of wounds healed	Somewhat congested, lymphoid nodules noted	Slightly congested	6	No contraction	Normal	Return clear	Right antrum normal
Normal, margins of wounds healed	Normal	Normal	62	No contraction	Normal	Return clear	Left antrum normal
Normal, margins of window healed	Normal	Normal	26	No contraction	Normal	Return clear	Lining membrane thickened
Normal, margins of window healed	Normal	Normal	29	No contraction	Normal	Return clear	Lining membrane thickened

† In case 4 the middle mental approach was used in irrigating the antrum at the time of the final examination, even though the window had closed. The tissues had the same characteristics as a normal pars membranacea. Roentgenogram made after injection of iodized oil showed a small filling defect inferiorly in case 3.



by intermediate squamous epithelium. There is chronic inflammation in the mucous glands. A small fragment of bone is attached to the base. This contains loose connective tissue in the medulla, and the cortex seems to be partially decalcified.

CASE 2 (Mrs O M B) —There is a small bit of columnar epithelium with much acute and chronic inflammatory exudate.

CASE 3 (Mrs N G) —Sections show a mucous membrane lined by columnar cells. Beneath this there is chronic inflammation, also a few spicules of bone.

CASE 4 (C G B) —There is one single fragment of bone. The other specimen consists of a mucous membrane lined by columnar cells and containing mucous glands. No inflammation is seen.

CASE 5 (Miss A L N) —The site of this tissue cannot be determined with certainty. The large number of mucous glands underlying the covering columnar cells suggests that the tissue came from the nose of the nasopharynx. It shows acute and chronic nonspecific inflammation.

CASE 6 (Mrs L W) —There is a small bit of columnar epithelium with a chronic inflammatory exudate.

CASE 7 (Miss A J W) —The specimens consist of serous glands covered by columnar epithelium. There is slight chronic inflammation.

CASE 8 (Mrs F P, right antrum) —Although there is some edema as well as some lymphocytic and plasma cell infiltration, the most interesting feature is the presence of hemosiderin-laden phagocytes. The mucosa in itself is not remarkable.

CASE 9 (Mrs F P, left antrum) —There is minimal chronic submucous inflammation. The most interesting feature is ectopic calcification of the stroma. Sometimes these foci are concentrically laminated like psammoma bodies.

CASE 10 (N C) —A tiny mass of mucous glands partly covered by columnar epithelium shows hemorrhage, edema and acute inflammation.

CASE 11 (E E T) —A narrow strip of mucous membrane is covered on two sides by pseudostratified columnar epithelium. It contains many mucous glands, a few of which are cystic. There is minimal chronic inflammation.

CASE 12 (V M B, right antrum) —Sections show mucous membrane lined by columnar epithelium. Some areas of necrosis are noted. Chronic inflammation is seen.

CASE 13 (V M B, left antrum) —The section shows polypoid masses of tissue covered by pseudostratified columnar epithelium of varying thickness and with a loose, almost myxomatous stroma. The stroma is heavily infiltrated by eosinophils, plasma cells and lymphocytes.

#### SUMMARY AND COMMENT

This series is too small for one to be able to deduct any definite conclusions.

Many men who oppose making a window in the middle meatus without radical maxillary sinusotomy make such an opening when doing radical antrotomy or radical antrotomy and ethmoid exenteration though they consider it unnecessary for complete ethmoidectomy. In some instances the opening is made through both the inferior and the middle meatus. This apparently paradoxical attitude has not been explained satisfactorily.

One patient, after the injection of india ink, had acute pain for thirty minutes. He had no other symptoms. Some tenderness was present over the antrum for three days. Some of the ink may have penetrated the soft tissues, although the ink was observed in the middle meatus after the injection.

It was difficult, after india ink had been injected into the antrum, to observe the fine streaks in the middle meatus. Various types of lights both with and without magnification were tried but were of little aid. A fine probe with cotton wrapped around the tip was touched to the middle meatus from time to time and then observed for deposits of india ink. This method was satisfactory.

Neither abscess formation nor infection nor webs of scar tissue occurred within the antrum in those cases in which the antral ostium had been removed or traumatized. Ciliary action continued as normal after the experimental surgical treatment.

Of the 32 patients who were operated on for chronic or subacute maxillary sinusitis, only 13 returned for a final examination. The other 19 stated that they had had no symptoms and felt "too good to visit a physician." Of the 13 patients on whom a final examination was made, 12 had had no infection of the upper respiratory tract. Two complained of occasional nasal blockage. Four had occasional headaches. Eleven stated that the amount of nasal discharge was apparently normal, while 2 felt that it was more than normal. Of these 13 patients, 7 felt that they were cured, 5, though they had occasional minor nasal complaints, felt that these were of a minor nature, and the one who continued to have occasional infections of the upper respiratory tract thought that he was improved.

A former member of the rhinologic staff of Washington University has been helpful in the preparation of this paper. His name has been omitted at his request, as he no longer is specializing in rhinology.

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## SYMPTOMATIC ELONGATED STYLOID PROCESS

Report of Two Cases of Styloid Process—Carotid Artery Syndrome with Operation

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SOME of the obscure, as well as common, pharyngeal pains, painful deglutition and referred otalgia may be traced to an elongated styloid process<sup>1</sup> It is of interest that these symptoms are usually found only after tonsillectomy I now hope to establish that the elongated styloid process may also cause facial pain and headache, even when tonsillectomy has not been performed, owing to impingement of the process on a carotid artery Thus, there exist two distinct syndromes referable to the styloid process, these syndromes present groups of symptoms which differ in their anatomic locations

The classic, and commoner, syndrome usually relates all symptoms to the pharynx and the ear, but occasionally an atypical group of symptoms may be referred to the hypopharynx and the upper part of the esophagus<sup>1f</sup> The second syndrome, which I shall designate as the styloid process—carotid artery syndrome, presents symptoms related to the pattern of distribution of either the internal or the external carotid artery

### HISTORICAL REVIEW

The historical background of the elongated styloid process is interesting, but it suffices now merely to recall that the elongated process occurs in approximately 4 per cent of persons, but that only a few of these persons have symptoms It is of further historical significance that the elongated styloid process had been of anatomic rather than clinical interest until the recent past The elongated styloid process may be hereditary, as my associates and I have found 3 siblings, the

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1 (a) Stirling, A W On Bony Growths Invading the Tonsil, *J A M A* **27** 734 (Oct 3) 1896 (b) Thigpen, C A Styloid process, *Tr Am Laryng, Rhin & Otol Soc* **38** 408, 1932 (c) Eagle, W W Elongated Styloid Process, *Arch Otolaryng* **25** 584 (May) 1937 (d) Fritz, M Elongated Styloid Process, *ibid* **31** 911 (June) 1940 (e) Loeser, L H, and Cardwell, E P Elongated Styloid Process, *ibid* **36** 198 (Aug) 1942 (f) Eagle, W W Elongated Styloid Process Further Observations and a New Syndrome, *ibid* **47** 630 (May) 1948

only siblings of the family, all of whom had symptoms immediately after tonsillectomy. The elongated process may be found in young adults, but is oftener observed in patients 30 years or older. In 1 case we found an elongated process during tonsillectomy in a child aged 14.

At the turn of the century, keen clinical observations caused the elongated process to be considered the origin of a definite clinical entity. The normal styloid process is approximately 2.5 cm (1 inch) in length, and any process beyond this length may be considered elongated. It is conceivable that a styloid process of normal length may be symptomatic when a deviation in the axis at the tip of the process occurs, impinging against either the external or the internal carotid artery and causing disturbance in the circulation in the artery, as well as stimulation of the sympathetic nerve fibers in the arterial walls. The tip of the process normally lies between the internal and external carotid artery, and the process is usually fairly straight, with the entire shaft pointing a little medially. There are three small muscles and two ligaments attached to the styloid process, but the function of the muscles is not important or very well known. Certainly, the muscles can be of no great significance, because after their resection in the operation of shortening the styloid process the patient notices no abnormality in the functions of swallowing or speech.

#### CLASSIC SYNDROME

The classic syndrome produces a typical sequence of symptoms, which almost constantly occur immediately after tonsillectomy. The patient complains of pain in the throat throughout the entire convalescence and then continues to complain of a sore throat during the ensuing years. Patients actually believe that the throat never healed after the tonsillectomy. They sometimes have the sensation that a foreign body, such as cotton, spicules of wood, or even metallic substances, is lodged in the throat. There may be difficulty in deglutition, and considerable pain may occur during the act. Frequently, pains are referred to the ear on the side of the elongated styloid process. The difficulty in swallowing may involve not only the pharyngeal muscles, but also the constrictor muscles of the upper part of the esophagus and the hypopharynx. The pharyngeal symptoms are composed of nagging and dull, aching pains, which become much worse during the act of deglutition, in addition, there may be a sharp pain in the pharynx. The pain is in no way comparable to the momentary, lancinating pains, of extremely severe character, that occur in cases of glossopharyngeal neuralgia. The pharyngeal pains are due to the stretching or fibrosis that occurs during the post-tonsillectomy healing in the sensory nerve endings of the fifth, seventh, ninth and tenth cranial nerves, all of

whose branches supply the involved area. It is rare for the patient to have symptoms of the classic type when the tonsils have not been removed.

In tonsillectomies, especially in instances in which a snare or guillotine is used, the surgeon has undoubtedly encountered the elongated styloid process, and this abnormality not only caused difficulty during the operation but prevented the total removal of the tonsils, with subsequent bleeding. With the dissection method of tonsillectomy the elongated styloid process will also be encountered, but it will cause a minimal handicap to the thorough removal of the tonsil. Should the elongation of the styloid process be bilateral, the symptoms may be bilateral. Many patients, however, who have bilateral elongation of the processes also have no symptoms.

#### STYLOID PROCESS-CAROTID ARTERY SYNDROME

The symptoms of this syndrome may occur whether the tonsils have been removed or not. Any styloid process, especially the elongated one, whose tip deviates medially or laterally may cause considerable pressure on the internal or the external carotid artery, not only impairing the function of the vessel by diminishing the caliber, but also causing most pronounced symptoms by irritation of the sympathetic nerve fibers, which form a rich supply to the walls of the carotid artery. There is oftenest a variation in the location of the bifurcation of the common carotid artery, and, since near the bifurcation the external carotid artery may lie more medial than the internal carotid artery, confusion may exist in interpretation of how the internal carotid artery could be affected when the position in the neck is supposedly that of the external carotid artery.

When the elongated styloid process impinges on the carotid artery considerable tenderness may be elicited locally on palpation over the artery. Frequently, a tender artery is mistaken for tender cervical lymph nodes when the artery is superficial. Lymph nodes overlying the artery are always tender. Carotodynia, as described by Fay, could be due to an elongated styloid process. In some instances the elongated process may actually be palpated just posterior to the mandible, or as it extends beneath the lower edge of the mandible, especially in those cases in which there is little subcutaneous tissue or the process is extremely elongated. The pinching of the carotid artery will cause distribution of pain in the pattern of distribution of that artery. This is of diagnostic significance, because the areas of the head supplied by the two carotid arteries are entirely different. Persons in whom the internal carotid artery is involved will complain of parietal headaches and head pains throughout the distribution of the ophthalmic artery, which is the normal area of distribution of the internal carotid artery.

Little or no pain will occur below the level of the eye. In cases in which the external carotid artery is affected the pain will be referred to the region below the level of the eye, in the region normally supplied by the numerous branches of the external carotid artery.

It is quite probable that in many cases in which pain and headache occur on one or both sides of the head an elongated process may be the cause of the symptoms. This is a probability to be considered in cases in which a diagnosis has otherwise been obscure, difficult or even impossible. Some patients are undoubtedly treated for histamine sensitivity, migraine or vascular headaches when their symptoms are really due to pressure on a carotid artery by an elongated styloid process which deviates at the tip. It is well to remember that in the styloid process-carotid artery syndrome tonsillectomy does not necessarily precede the onset of symptoms.



Fig 1—Diagram demonstrating the ease with which the palpating finger locates the elongated styloid process

#### DIAGNOSIS

The diagnosis of an elongated styloid process, or even one that is not elongated but is symptomatic, should not be difficult. In cases of the classic syndrome the history of the symptoms following a tonsillectomy is always most suggestive, and the palpating finger provides evidence for definite conclusions. Roentgenograms give still further confirmation. To palpate the elongated process, the curved index finger is placed in the open mouth—not too widely open—and the tip of the finger is inserted into the tonsillar fossa (fig 1). It is most important that the palpating finger not be allowed to glide over the base of the tongue, which sets up a severe gag reflex, for palpation is a fairly easy procedure to perform if the tip of the finger is carefully placed in the tonsillar fossa. If a firm resistance is met by the palpating finger in the

tonsillar fossa, it can only be an elongated styloid process that is felt. A styloid process of normal length is never palpable. The presenting portion which is palpated is most likely to be the tip of the process, or it may be a portion of the calcified stylohyoid ligament. If the patient's symptoms are due to the elongated process, he will wince from pain as the palpation is performed, he will state that the palpation produced exactly the same symptoms as those he usually experiences, though perhaps of severer intensity. The diagnosis is then quite clear, because the elongated process is the only possible firm structure which can be palpated beneath the tonsillar fossa and be painful on palpation. In order to ascertain the exact length of the styloid process, lateral roentgenograms are necessary. The lateral views are also valuable at the time of the surgical shortening in determining the length of the segment of the elongated process which is to be resected.

If the patient exhibits symptoms of tenderness and compression of the carotid artery, it may be necessary to palpate through a tonsil, a procedure which is not very satisfactory if the tonsil is large and thick. Even so, much tenderness will be elicited on palpation through the tonsil. If the tonsils have been removed, the elongated process is easily demonstrated by palpation. With one palpating finger in the tonsillar fossa and another placed externally on the neck, extreme pain may be elicited. It is necessary in all cases in which the styloid process is suspected of causing symptoms referable to the carotid artery to have posteroanterior roentgenograms, because this view will demonstrate any deviation of the process in the shaft itself and, of the greatest importance, at its tip. The lateral roentgenogram is again utilized in determining the total length of the process and the length of the segment to be resected. The deviation at the tip of the process may project either medially or laterally, a position which may or may not give some indication as to whether the internal or the external carotid artery is impinged on. The distribution of the pain denotes which artery is involved. By injection of a radiopaque substance into the blood stream of the common carotid artery, it should be easy in doubtful cases to demonstrate on the roentgenogram the exact artery involved and how tightly embedded the process may be against the arterial wall. The latter diagnostic procedure has not been necessary or advisable in the cases under our observation in which the presence of the styloid process-carotid artery syndrome was suspected.

#### DIFFERENTIAL DIAGNOSIS

There should be little difficulty in differentiating the typical, so-called classic, syndrome. The tonsils will have been removed, and the symptoms will have followed the operation. The palpating finger in the tonsillar fossa is the differentiating factor. There may be some difficulty in

eliminating the possibility of sphenopalatine ganglion neuralgia or temporomandibular joint syndrome or the role of an unerupted and impacted third molar. The laboratory studies should to some extent clear these various problems. Cocainization of the sphenopalatine ganglion would certainly not eliminate the symptoms in the pharynx with referred pain to the ear due to an elongated styloid process. The patient with the temporomandibular joint syndrome probably has a history of partial or total molar extraction just prior to the onset of symptoms, or he will admit sleeping on his face with his chin pushed by his hand or pillow to one side—the side on which he is having pain. The presence of an unerupted and impacted third molar can be diagnosed easily by observing the absence of that molar, with no history of extraction, and roentgenographic demonstration of the impactions. Glossopharyngeal neuralgia is easily distinguished by the sudden, lancinating pain in the pharynx of short duration, usually brought on by the stimulation afforded by hot or cold foods, liquids or even the movements of the tongue in the pharynx.

#### TREATMENT

There is only one satisfactory and sure method of alleviating the symptoms due to an abnormal styloid process—the surgical shortening of the elongated process or the surgical removal of a tip of a process of normal length that may be impinging on a carotid artery.

The intraoral surgical route is preferred and is, indeed, the simpler route of approach. The external approach<sup>1e</sup> necessitates an undesirable external scar on the neck and along the lower border of the mandible. The intraoral route requires no different setup for anesthesia and approach than the exposure for tonsillectomy. The Davis-Crowe mouth gag is preferably used, with light anesthesia induced with ether passed through the tongue blade to the area just above the glottis. The light anesthesia insures that the cough reflex, which prevents the aspiration of any blood or secretions, is never abolished. Suction is also used throughout the operation. The foot of the operating table is elevated, which further prevents any aspiration. As the operation is completed, the patient is usually able to converse with the operator after the mouth gag has been removed, though not necessarily in a coherent manner. The need for nursing care after an operation with light anesthesia is therefore reduced to a minimum, since the patient returns to the ward rather well recovered from the anesthesia. (The nursing problem in all hospitals today is to be considered seriously.)

The operation itself requires the longitudinal separation of the mucosa at the point of palpation of the process in the tonsillar fossa, with the immediate separation of the muscles beneath the mucosa. This opening is best made with the right-angled tonsillar scissors opened



wide. The palpating finger is then inserted into the open wound, and the denuded tip of the styloid process is immediately recognized. The palpating finger is used to dissect free all the muscle attachments on the medial and anterior portions of the styloid process, and then a curved septal elevator is used to dissect the muscles from the lateral and posterior insertions on the styloid process. The stylohyoid ligament has, in the meantime, presented itself clearly and is then resected. If in a case of the styloid process-carotid artery syndrome the tonsils are present, the aforementioned procedure is carried out after the tonsillectomy, the tonsillectomy being required for access to the styloid

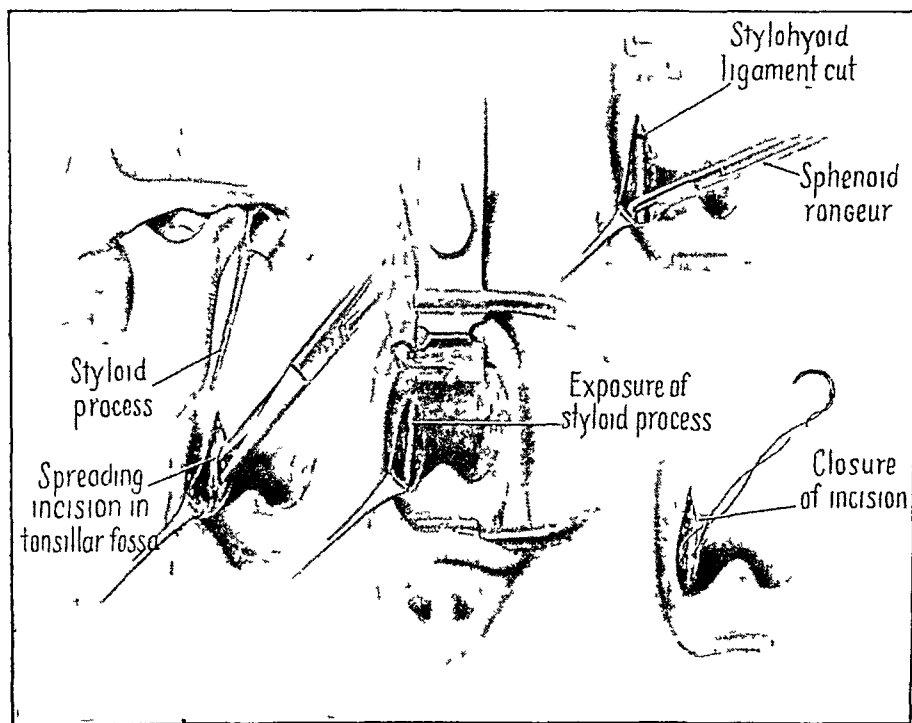


Fig 2—Stages in the technic involved in the intraoral shortening operation of the elongated styloid process

process. It is a pleasure to shorten a styloid process in a fresh tonsillectomy wound, since there is no scar tissue to deal with (fig 2).

The lateral roentgenograms have already demonstrated the entire length of the styloid process, and since one wishes to leave a stump no longer than 2.5 cm, it is easy to determine how much of the elongated process is to be resected. A clamp should grasp the distal end of the process as the segment is broken free by a Hajek sphenoid forceps, otherwise, any muscles still attached may retract the resected portion into the muscular field, and it is then very difficult to locate the freed segment. There is no bleeding in the average case, since no blood vessels are actually severed and the approach is made entirely by

longitudinal dissection in the tonsillar fossa and muscles. Should bleeding occur, it is easily controlled by O surgical gut sutures. Infections of the parapharyngeal space are avoided by the insertion of sulfanilamide powder into the wound before closure. The sulfanilamide powder is preferred to the powder of any other sulfonamide drug because of its universal action on streptococci, staphylococci, fusospirochetal and anaerobic organisms. The muscles and mucosa are closed with plain O surgical gut sutures.

The immediate postoperative period is calm and not too painful. There is much less pharyngeal discomfort after operation on the styloid process than after a tonsillectomy, since in the operation on the styloid process the wound is closed tightly, thereby preventing secondary infection or a granulating open wound. The patient is able to leave the hospital on the third or fourth postoperative day. Occasionally, swelling



Fig 3 (case 1) —The ram's horn type of elongated styloid process, in this case the tip fitted tightly against the external carotid artery.

may occur in the neck, which I believe is due mainly to sensitivity to the sulfonamide powders left in the wound, for little swelling occurs in the pharynx itself.

### RESULTS

The operation for surgical shortening of the styloid process has in our experience always produced excellent results. Other procedures short of the actual shortening of the process, such as fracturing of the process by the palpating finger, have only partially alleviated the symptoms, and the results cannot compare at all with the results of the surgical resection.

### REPORT OF CASES

**CASE 1** *External Carotid Artery Syndrome*—Mrs R S, aged 67, reported on previously,<sup>1†</sup> was our first operative patient who had symptoms suggestive of an elongated styloid process, with impairment of function of the external carotid artery.

and pain along the distribution of the artery on the left side of the head. The operation for shortening the process was performed in August 1946. The tip of the process was tightly wedged against the left external carotid artery, causing quite a constriction of the lumen, as well as considerable compression of the sympathetic nerves in the arterial walls. It was resected. The postoperative convalescence was quiet, and the results were excellent with relief of pain immediately after the operation (fig 3).

**CASE 2** *Internal Carotid Artery Syndrome*—W J P, a man aged 39, was first seen on Feb 10, 1948. He gave a history of severe pain in the left frontal area and vertex of five years' duration. The pain usually occurred every two to four days and lasted two to four days. All teeth had been extracted and replaced with plates, and there was no suggestion of the temporomandibular joint syndrome.



Fig 4 (case 2)—Retouched posteroanterior roentgenogram, demonstrating the medially deviated tips of the elongated styloid processes, in this case the right styloid process was longer than the left but was asymptomatic, the left one was symptomatic only because it was tightly embedded on the left internal carotid artery.

The tonsils and adenoids had been removed, and he had had surgical treatment of the intranasal sinuses many years previously. His hearing and vision had not been impaired, although there was occasional tinnitus in the left ear. The findings on physical examination were normal in every respect except for the bilateral elongated styloid process. Laboratory studies, including serologic tests of the blood revealed no abnormality. The styloid process was definitely elongated bilaterally, the right being a little longer than the left and each being more than 5 cm in length. Each process showed a medial deviation just above the tip. Since the patient's headache and head pains coincided with the area of distribution of the left internal carotid artery, it was thought that his symptoms were due

to impingement of the elongated styloid process on the vessel and the sympathetic nerves in the vessel walls, with disturbance of their function. On Feb 12, 1948 the patient had bilateral shortening of the elongated styloid process, although only the left process was considered symptomatic. A total of 3.5 cm was removed on each side. He was seen in a follow-up examination on May 15, 1948 and was found to be completely free of the headaches and head pains. He has now pain on the left side of the pharynx, at night only, this is thought to be due to formation of scar tissue in that area, and we feel certain that pain will eventually subside (fig 4).

#### COMMENT

Further knowledge and experience have been attained in dealing with the symptomatic elongated styloid process. The classic syndrome pains in the pharynx and ear due to an elongated styloid process is now more frequently recognized and successfully treated than in previous years. In very recent years a syndrome has been recognized in which tenderness of a carotid artery on palpation is associated with an elongated styloid process and coexistent headaches or head pains in the pattern suggestive of irritation of a carotid artery. Previously these symptoms had evaded diagnosis, but it is now recognized that they represent the styloid process-carotid artery syndrome. Therefore, it is our impression that some headaches are caused by an elongated styloid process and that these headaches occur when a tip, or even the shaft, of a styloid process projects either medially or laterally to cause pressure on either the external or the internal carotid artery. The symptoms, when present, will invariably occur in the pattern of distribution of the internal or the external carotid artery. The syndrome has been easily confused with the vascular or histamine type of headache and pain. The possibility of this syndrome should certainly be considered, or at least eliminated, in all cases in which the distribution of pain lies in the pattern of distribution of either of the carotid arteries. Roentgenograms should certainly be utilized to determine the length of the styloid process and the status of the tip of the process in its relation to the carotid arteries, even in cases in which tonsillectomy has not been performed. It is inexcusable not to use the palpating finger in the tonsillar fossa for diagnostic purposes, this palpation should be done routinely on all patients complaining of headaches or pains suggestive of a dysfunction of the carotid artery. Arterial injections of a radio-opaque material should be resorted to when there is not a roentgenologically visible or a palpably elongated styloid process, or when the presence of an abnormality, such as a deviated tip of a process of normal length, is suspected.

#### SUMMARY

The symptomatic elongated styloid process produces a characteristic group of symptoms. These symptoms may occur in two distinct groups: (1) the classic syndrome, always occurring after tonsillectomy, with

the symptoms involving the pharynx and hypopharynx, with referred pain to the ear, and (2) the styloid process-carotid artery syndrome, in which symptoms are produced along the distribution of an external carotid artery or an internal carotid artery by impingement on the vessel, affecting the circulation in the vessel and producing irritation of the sympathetic nerves in the arterial sheath. A process of normal length may have a deviated tip producing the symptoms, and tonsillectomy does not necessarily precede the onset of symptoms in the styloid process-carotid artery syndrome.

The symptoms, diagnosis, differential diagnosis, surgical treatment and results of operation are discussed. Two cases of the styloid process-carotid artery syndrome are reported, in both of which operation was performed. In the first case the symptoms related to the external carotid artery, while in the second case symptoms referable to the area of distribution of the internal carotid artery were exhibited. An attempt has been made to demonstrate that the styloid process-carotid artery syndrome may be the disease underlying many of the undiagnosed and obscure head pains and aches which have been treated unsuccessfully, because they were thought to be due to migraine, vascular spasm, histamine sensitivity and similar conditions.

The palpating finger is most useful in reaching a diagnosis, because it will invariably find an elongated styloid process beneath the tonsillar fossa, when it exists. Digital palpation should always be performed in the tonsillar fossa in all cases in which symptoms of pharyngeal or facial pain exist. Roentgenograms are useful for confirmation of the information derived from digital palpation. Posteroanterior roentgenograms are necessary in all cases in which the styloid process-carotid artery syndrome is suspected.

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#### ABSTRACT OF DISCUSSION

DR C M KOS, Iowa City. While the symptom complex of local and referred pharyngeal pain is neither in part nor in its entirety an unfamiliar one, its various causes are sometimes elusive. It is possible that the thesis on which the styloid process-carotid artery syndrome is based may resolve in part the mystery attached to that group of symptoms currently classified as atypical facial neuralgia. The styloid process may be responsible for an even greater variety of symptoms than is generally admitted. Further discussion of this subject is unwarranted in view of the reported successful results obtained by segmental amputation of the styloid process. With this understanding it is not my intention to dispute the proposition of the symptomatic styloid process or the stylocarotid artery syndrome, I wish rather, to inquire further into certain aspects of them.

Anyone who searches for the elongated styloid process will find it. In some cases it may be symptomatic, in others, not. In most instances the symptomatic styloid process is observed after tonsillectomy. This evokes the question whether

surgical trauma to the styloid tip when it projects into or presses against the tonsillar fossa may establish osteitis or periosteitis and produce the symptom of pain. Such a possibility could explain the apparent tenderness over the adjacent carotid vessels and the presence of palpably sensitive lymph nodes in that area. If the pharyngeal pains are due, as Dr Eagle describes, to stretching or fibrosis that occurs during post-tonsillectomy healing in the sensory nerve endings of the fifth, seventh, ninth and tenth cranial nerves, it would be unnecessary to implicate the elongated styloid process except as an incidental finding.

The styloid process is a vestigial structure, according to the opinions of comparative anatomists, hence it is present at birth and undergoes little alteration with respect to other cervical structures during the process of growth. Consequently, when it extends beyond its usual length of 2.5 cm it should give rise to symptoms long before the age at which it is ordinarily observed to become clinically significant, particularly as it may be related to the designated styloid process-carotid artery syndrome.

The hypothesis is presented that stimulation by pressure of the deviated or elongated styloid process causes distribution of pain over the patterns of the external or the internal carotid artery. However possible this may be, comparison by analogy is difficult. Any such analogy may be evidenced by inducing pressure by palpation, which should produce facial or cephalic pain. Compression by tumors over the carotid artery should have a similar effect. There is little conclusive evidence to show that this is so.

Since the elongated styloid process projects between the normally disposed external and internal carotid arteries, an unusual deviation causing pressure might from time to time produce symptoms similar to any of the three manifestations of the carotid sinus syndrome, no such correlation has been made, and pain is not a part of that clinical entity.

The elastic structures of the neck are exposed to variable alterations in pressure resulting from postural relations of the head and neck to the shoulder girdle. It is conceivable that this influence together with that of the elongated styloid process might cause variations in the intensity of the symptoms in either the classic symptomatic complex or the styloid process-carotid artery syndrome. Such an observation has not been noted here, though the act of deglutition has been mentioned as a source of aggravation of pain.

I consider this subject a provocative one, yet I know from personal association that Dr Eagle has gathered substantial evidence. His study should excite curiosity and lead to more extensive exploration of the problem.

DR O E VAN ALYEA, Chicago. Dr Eagle has revived an old entity and presented a new syndrome. An elongated styloid process is a condition known to most otolaryngologists, and the styloid process-carotid artery syndrome is worthy of their consideration. Any help to be gained in determining the cause of vague pains about the face is welcome. Certainly, the pain of many such patients fails to fit into the established clinical classifications and, accordingly, fails to respond to known therapeutic measures. Some of these could well fall into the styloid process-carotid artery category.

The elongated styloid process is an embryonic defect. The styloid bone develops, along with the stapes, the stylohyoid ligament and the anterior horn of the hyoid bone, from the cartilaginous core of the second branchial arch. The length of the styloid process depends on the degree of ossification in the proximal portion of Reichert's cartilage. It is easy to understand how variables may occur, as they do in other bony structures of the body.

Dr Eagles states that the process is abnormally long in 4 per cent of persons, but that symptoms of pressure are present in only a small percentage of these persons. Some authors state that symptoms are present only in persons who also have calcification of the stylohyoid ligament. I should like to ask Dr Eagle whether he feels that such calcification is necessary for the production of symptoms of pressure.

Dr Eagle kindly sent me a copy of his paper a few weeks ago, and since then I have been on the alert for elongated styloid processes. To date, I have not resorted to roentgenographic study but I have palpated the tonsillar fossa of many patients, and I feel that this simple measure could well be adopted in the routine search for the cause of the symptoms described in this paper.

DR L. A. NELSON, Dallas, Texas. I believe that the hyoid bone may produce the same symptoms as those described by Dr Eagle. The hyoid bone has from two to three bursas, or small series of sacs, on the posterior part of its body, and rheumatoid disease of the hyoid bone was reported in *The Journal of the American Medical Association* about fifteen years ago. Exertion of pressure from the tips of the greater cornua to the hyoid bone in cases in which this bone is involved produces pain corresponding to the pain the patient complains of. The pain of this syndrome responds to treatment for rheumatic infections, such as the use of salicylates, this treatment would certainly be much easier to try out than an operative procedure on the styloid process. Usually, a week's medication completely relieves the situation, and relief may continue for some time. However, the condition does recur. The mechanism of its recurrence is best seen in cases in which the tonsils have been removed. The scar formation probably changes the tension on the structure as a whole, particularly on the bursas of the hyoid bone, and makes it subject to easy infection.

The fact that the condition responds to treatment may well be considered.

DR MURDOCK EQUEN, Atlanta, Ga. Dr Eagle's presentation has been most interesting. I should like to present a case illustrating the possibility of trauma of the styloid process during a dental procedure. A woman aged 45 suffered severely after the extraction of an impacted molar on the left side of the upper jaw. The extraction was most difficult and painful, and she stated that during the procedure she jumped around in the dental chair. Phenobarbital USP, codeine and even morphine failed to relieve her pain. Her mouth was opened with a great deal of difficulty, and on palpation a fractured styloid process on the left side was found, this finding was corroborated roentgenographically. The patient was anesthetized, and the left tonsil was removed. This gave adequate access to the styloid process. The fractured styloid process was found and removed, and the patient made an uneventful recovery. It is difficult to see how a dental procedure could possibly result in fracture of the styloid process, but the patient's poor cooperation with the dental surgeon, no doubt, accounted for the resulting trauma.

DR WATT W. EAGLE, Durham, N. C. In reply to Dr Kos's question. It has never been my impression that osteitis or periosteitis had occurred in these cases. If so, the infection would have had to exist for twenty or thirty years in some cases.

Dr Nelson is speaking of a different condition from the symptomatic styloid process when he states that palpation of the styloid process produces immediate pain, it reproduces the original pain. The patient may jump out of the chair when the symptomatic styloid process is touched, as did the patient Dr Equen.

spoke of I do not palpate as deep as the hyoid bone The stylohyoid ligament may become calcified

Someone asked about the calcification of the stylohyoid ligament On only two occasions clinically have I found it calcified all the way to the hyoid bone In the anatomic dissecting rooms, however, many cases may be found among the Negro cadavers

I have seen patients in whom the styloid process was so prominent that the mucous membrane of the pharynx would glide over this process as the mouth was opened Such stimulation may produce pain in the ear, and pain of the same type may be produced by stimulation of the endings of the fifth, seventh, ninth and tenth cranial nerves as swallowing takes place

I thank Dr Van Alyea for discussing the embryonic origin of the styloid process One patient, the youngest in the series, who had his tonsils removed at the age of 25, had elongated styloid processes Most of the patients are at least in their thirties, so that there has been sufficient time for the ossification to take place

I have seen some patients who, as Dr Jackson told us several years ago, may have had arthritis of the larynx They did not have elongated styloid processes, and their condition improved with the wearing of a flannel band around the neck or with the use of salicylates, as Dr Nelson pointed out



# RADIATION THERAPY FOR CONDUCTIVE DEAFNESS

## Report of Results and Discussion of Roentgen and Radium Irradiation

HARRY C ROSENBERGER, M D  
CLEVELAND

THE WORK of Crowe and associates at the John Hopkins University has initiated and popularized radium irradiation of the nasopharynx for a certain type of deafness. That radium was successfully used for aerotitis in the recent war is well known from the numerous enthusiastic reports of the air and submarine forces. Bordley<sup>1</sup> stated that irradiation of the nasopharynx resulted in "appreciable useful increase in hearing acuity" in 45 per cent of the children selected for treatment of conductive deafness. He further stated that only 25 per cent of selected adults showed such improvement. Full page advertisements of the radium applicator in the special journals urge its use in such allied conditions as recurring attacks of acute otitis media, obstinate cases of chronic otitis media and certain types of cough and asthma. This is a large order.

### MODE OF ACTION

The therapeutic action of the monel metal radium applicator is the effect chiefly of the beta rays on the germinal centers of the lymphoid follicles resulting in lessened mitosis and increased formation of fibrous tissue and thus in shrinkage of the lymphoid mass. The therapeutic objective is the relief of tubal blockage resulting from hyperplasia of the lymphoid follicles and edema of the mucous membrane. These are established facts. The tissue response to roentgen irradiation and the therapeutic objective are identical with those stated for the use of radium.

### NATURE OF STUDY

I am reporting the hearing results of 21 patients referred to the radiologic laboratory of Hill, Thomas, Farmer, Sackett and Schumacher over the past five years. The purpose of the reference was roentgen irradiation of the nasopharynx for diminished hearing of conductive type thought to be caused by tubal blockage of lymphoid origin. I also wish to present my reasons for the use of roentgen rather than radium irradiation.

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<sup>1</sup> Bordley, J. E. The Use of Radium in the Treatment of Conductive Deafness, Surg., Gynec. & Obst. **84** 839-844 (April, no. 4A) 1947

Of the 21 patients, 13 were boys and 8 were girls. The age range was from  $2\frac{1}{2}$  to 14 years. Reference for irradiation was always preceded by a hearing test, usually an audiometer test of air and bone conduction. In every instance the tonsils and the adenoids had been removed weeks to years previously. In most instances local treatment of the nose and throat had been given together with a trial of tubal inflations by various technics. Postirradiation hearing tests were always made several weeks after the last irradiation to permit the full effect of irradiation to be realized.

#### SELECTION OF PATIENT

The selection of the patient was on the basis of the history, the otologic examination, the examination of the nasopharynx, either by mirror or by electric nasopharyngoscope and finally the hearing tests. In addition, the patient was showing little if any improvement following standard otologic treatment. The typical patient was one who had had recurring colds, frequently associated with differing combinations of otalgia, stuffiness of the ears, tinnitus and variable hearing. In some instances the patient had had one or more attacks of suppurative otitis media, but in none was the nasopharynx irradiated until the ears were dry and healed.

Otologic examination usually revealed pink, retracted tympanic membranes, although lusterless, thickened membranes were occasionally seen. In no instance was a fluid level or "bubbles" seen as in adult secretory catarrh, but by auscultation with the Toynbee tube one could occasionally readily demonstrate the presence of moisture. In only the exceptional instance did nasopharyngoscopic examination encounter any evidence confirmatory or diagnostic of obstructing lymphoid tissue. More will be said of this later. The audiometric curve was more often flat than tipped in the low tone range.

#### RESULTS OF IRRADIATION ON HEARING

Of the 21 patients whose nasopharyngeal tissues were irradiated, only 7, or one third, showed significant improvement of hearing, but in several of these the gain amounted to as much as 30 decibels in the critical frequencies. In view of the lack of benefit from treatment prior to irradiation the result is significant. Each patient of the present group had a total of four treatments, and in no instance were subsequent treatments given. It is possible that additional treatments might have increased the percentage of favorable results. One disappointing feature was the recurrence of aural symptoms and of depression of hearing with subsequent colds, although in several patients the incidence of colds seemed lessened.

## DIFFERENCES IN RADIANT ENERGY

In making the choice between roentgen and radium radiation I was influenced by the following considerations. Since the filtration of the radium is low, being that afforded by 0.3 mm of monel metal or steel, the rays which are most effective with this relatively soft radiation are the hard beta rays. The effective radiation is limited to an area of a diameter of about 3 to 4 mm. Beyond this area the radium has no therapeutic effect. On the other hand, using roentgen radiation with the factors 200 kilovolts, 0.5 mm copper filtration at 50 cm target skin distance, one can treat the entire nasopharynx thoroughly and evenly.

The factors<sup>2</sup> which were used in the cases which I am reporting were as follows: 200 kilovolts, 0.5 mm copper plus 2 mm aluminum, 50 cm distance, 100 volts over the right and left sides, with a portal of sufficient size to cover the nasopharynx. The treatment was repeated at weekly intervals for four treatments.

## ADVANTAGES OF RADIUM IRRADIATION

One advantage claimed for the radium applicator is that of limiting the radiation effect to the definitely circumscribed area close to the tip of the applicator. This presupposes accurate information of the exact location of the offending lymphoid structure. It also implies the technical ability to place the tip of the applicator in precise juxtaposition with the lymphoid area to be treated, with an allowable error in placement of only a few millimeters if benefit is to result.

Another stated advantage of the radium technic is that it is available to the otologist, who should best know the procedure for its introduction and proper placement. The lack of any reported instance of serious mishap attending the otologic use of the applicator is indicative of its relative safety when necessary precautions are observed.

## POSSIBLE DISADVANTAGES OF RADIUM IRRADIATION

Opposed to the advantages mentioned are the following possible disadvantages. Of necessity the monel metal applicator is quite straight. It thus becomes impossible to engage its tip in the entrance of the eustachian tube. If the offending lymphoid tissue lies several millimeters within the pharyngeal lumen of the eustachian tube (the tube is about 35 mm in length) it is doubtful at best whether sufficient radiation would reach it. The exaggerated curve on the eustachian catheter sometimes necessary in order properly to engage the tubal entrance in inflation dramatizes the necessary and understandable

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<sup>2</sup> Information regarding the roentgen technic was furnished by the radiologic laboratory of Hill, Thomas, Farmer, Sackett and Schumacher.

remoteness of the straight radium applicator tip from this important area. In such a case a poor result would probably ensue.

A second cause of possible failure in properly placing the applicator is the position and the size of the cartilaginous tubal entrance, termed the torus tubarius, which presents variations depending on the child's age. In the young child the torus lies relatively lower and is less prominent than in the adult. Any otologist who will routinely palpate and visualize the nasopharynx through a Killian speculum while doing adenoidectomy will early appreciate the considerable variability of the size of the nasopharynx as well as of the torus in children of the same and children of different ages. This variability must directly affect the certainty of application of the radium applicator.

Not only may the lymphoid tissue producing tubal inadequacy be situated within the lumen of the cartilaginous portion of the tube, but it may occupy an extracartilaginous position. I refer to lymphoid masses adjacent to the torus and typically posterior to the torus, in Rosenmüller's fossa. Another location I have learned to inspect is that fold of mucous membrane called the plica salpingopharyngea. This fold covers an underlying muscle of the soft palate and is often encrusted with hyperplastic lymphoid follicles like barnacles on a keel. These masses may obstruct the tubal entrance.

Unhappily a third location and one quite unflattering in its implication is that of the "recurring" adenoid mass in the usual midline adenoid-bearing region. I believe the two chief causes of this so-called "regrowth" is the pernicious practice of removing the adenoids with too light or no anesthesia together with a failure to engage the adenotome or the curet high enough in the vault of the nasopharynx against the vomer. In other words, an adenoid remnant remains. Whatever the cause, the result regarding the hearing is occasionally deplorable. In these instances there must be accurate information concerning the exact position of the areas to be reached, together with correct positioning of the radium applicator. Naturally the beneficial results of irradiation will be in direct proportion to the attention paid to these details.

In my experience an important difficulty has been in visualizing the nasopharynx adequately in order to ascertain just where the radiation effect should be directed. The passing of an electric nasopharyngoscope through the nostril of a struggling, weeping, apprehensive and cantankerous child is often an exhausting experience for both the patient and the doctor. Too often the information obtained is questionable.

Even with the cooperative patient, the shrinking and anesthetic applications that one must use occasionally distort and disguise the pathologic tissues present so that wrong impressions ensue. The

indirect view obtained with the postnasal mirror, while probably more informing than that provided by the nasopharyngoscope, is too often not obtainable with the young patient. This all adds up to inadequate knowledge of the state of the nasopharynx. In this dilemma recourse is had to the obvious procedure of inserting the applicator to the presumed desirable location and then hoping for the best. Of course, there is the occasional recalcitrant child in whom general anesthesia must be produced before any examination or treatment can be given.

#### ROENTGEN IRRADIATION

In the two foregoing sections I have given a summary of some of the advantages and disadvantages of radium irradiation of the nasopharynx for deafness. Now what may be said of the relative advantages and disadvantages of roentgen irradiation for this purpose? An important advantage of roentgen irradiation is that a larger field is covered by the exposure. Consequently, whether the obstructing lymphoid tissue is in the tube, in Rosenmüller's fossa, in the posterior pharyngeal wall or on the plica salpingopharyngea it is exposed to the therapeutic ray. Needless to add, this is accomplished without mayhem or fisticuffs. This broader field of irradiation lessens the possibility of misapplication or misdirection of radiant energy.

A theoretic disadvantage inherent in the technic of roentgen irradiation is the necessity of projecting the rays through normal tissue structures to reach the abnormal tissues requiring treatment. Theoretic damage to the skin, the pituitary gland and other structures has been mentioned as a contraindication to this method of irradiation. However, with the treatments in the hands of a radiologist, these arguments would seem to be not serious.

#### IRRADIATION A HEARING CONSERVATION MEASURE

Since irradiation for deafness has its greatest usefulness in the young, it is not inappropriate to reemphasize the role that this procedure plays in the large field of the conservation of hearing. It is with the young that otologists have their greatest opportunity of usefulness in mending the harm that befalls the hearing apparatus. With adults the same effort often yields only paltry returns, measured in terms of improved or conserved hearing.

This obligation to conserve hearing in the young now transcends the field of the otologist and involves his colleagues, the pediatrician and the family doctor. Armed with chemotherapy and with antibiotics these practitioners now function as otologists in dealing with many of their patients. No longer does the specter of an unresolved otitis media or possible mastoiditis with its complications haunt these busy

doctors The early administration of the "superdrugs" stops the discharging of the ear and makes a rarity of surgical mastoiditis

But what are physicians doing about the many ears they are forced to see after the acute inflammation has subsided? Happily, most physicians realize their dual responsibility of curing infection and conserving function However, too frequently one still sees children who have had an acute infection of the ear ably cared for by a physician who, after the resolution of the infection, lost all interest in the impaired function All that otologists can do about this is to become more interested in the various aspects of the conservation of hearing

Another problem encountered in irradiating the nasopharynx for deafness is that of the child who has severe nerve deafness or who is congenitally deaf except for possible "tone islands" which may be of use in his rehabilitation My attitude toward this is identical with my attitude toward the problem of the removal of diseased tonsils and adenoids of such patients If there is even the smallest chance of improving the situation by correcting a factor contributing to conductive deafness, the correction should be done I have referred several such patients for irradiation

#### FIBROTIC CHANGES

An important observation may be made regarding the time to institute radiation therapy for deafness I doubt the necessity or wisdom of routinely irradiating the nasopharynx after every adenoidectomy Certainly, a thorough effort at accepted otologic treatment should precede irradiation However, irradiation should not be withheld until irreversible fibrotic changes occur in the tube or the middle ear, rendering permanent a deafness that might have been only temporary

A second observation has to do with adenoidectomy The need for irradiation can surely be much reduced by having the patient under full anesthesia, so that the removal of adenoid tissue by curet and adenotome can be thorough and painstaking Secondary palpation and inspection is an important part of the operation I have found the circular tonsil punch of much aid in removing lymphoid follicles about the torus and from the lateral pharyngeal wall and the plica salpingopharyngea

#### ALLERGY

A final word may be added regarding the surprising frequency of either a personal or a family history of allergy in this group of 21 patients It probably coincides with the observation that an increasing number of otolaryngologists are making, namely Allergy is playing an accelerated role in the practice of otolaryngology

## SUMMARY

Of 21 patients with impaired hearing who were selected for roentgen irradiation of the nasopharynx, one third had significant benefit from such treatment after standard otologic treatment had proved ineffective. It is possible that the percentage of patients whose hearing was improved might have been increased by additional roentgen therapy. It is evident that radiation therapy may be administered effectively by either roentgen or radium technic. Some of the advantages and disadvantages of each method are discussed. In order that the radiation technic may not be considered a bonanza for the otologist, the patients must be carefully selected and the results of treatment properly assessed and reported.

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## HEARING REEDUCATION WITHOUT THE USE OF HEARING AIDS

A Report, Analysis and Interpretation of the Results in Fifty Hard of Hearing Persons

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NEW YORK

METHODS devised to improve the function of impaired organs of hearing without effecting a physical change have been used at various times in the past one hundred years, principally in young subjects whose hearing was severely impaired or who were born deaf<sup>1</sup> These methods have been both educational and acoustic in nature, but only in recent years, since the great increase in the employment of hearing aids began, have they become available to the many thousands with less profound, acquired impairment of hearing—the hard of hearing, for it was found that when a hearing aid was worn, improvement in hearing, over and above that derived from the amplification of the instrument, could be derived from such treatment<sup>2</sup> As a result, hearing reeducation (acoustic training) of the hard of hearing has become a common procedure. But practically it is given only after a hearing aid has been fitted and with the express purpose of bolstering the instrument's performance. It must however be pointed out that many hard of hearing patients are unable to wear a hearing aid, namely those who, because of the degree or the pattern of their loss of hearing, cannot tolerate a hearing aid or tolerate one to a negligible or inadequate degree only, and those whose station, calling or temperament prohibits the wearing of a hearing device. This is no small group, on the contrary, there is good reason to believe that the majority of persons who experience difficulty in hearing belong in it. Strangely enough,

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From the Department of Otolaryngology of the New York Polyclinic Hospital

1 Itard, J. E. M. G. *Traité des maladies de l'oreille et de l'audition*, Paris, Méquignon-Marvis, 1821, vol. 2. Urbantschitsch, V. *Ueber methodische Horübungen und deren Bedeutung für Schwerhörige, Ertaubte und Taubstumme*, Vienna, W. Braumüller, 1901. Goldstein, M. A. *The Acoustic Method for the Training of the Deaf and Hard-of-Hearing Child*, St. Louis, Laryngoscope Press, 1939.

2 (a) Senturia, B. H., Silverman, S. R., and Harrison, C. E. A Hearing Aid Clinic, *Ann. Otol., Rhin. & Laryng.* **52** 131-145 (March) 1943. (b) Goodfellow, L. D. The Re-Education of Defective Hearing, *J. Psychol.* **14** 53-58 (July) 1942.



they have received no help whatsoever—neither hearing aid nor hearing reeducation. Since they are unable to receive the benefits of a hearing aid, it seems that at least an attempt should be made to provide them with the benefits derived from the reeducational portion of aural rehabilitation programs. Yet, with such a suitable field available, efforts to apply to unaided ears the type of therapy that is used in conjunction with hearing aids are practically unknown. To the best of my knowledge this is the first series of cases reported which directs attention to the possibility that auditory reeducation may be of use in those unable to wear a hearing aid.

#### FEASIBILITY OF AUDITORY REEDUCATION WITHOUT USE OF A HEARING AID

A patient with, for example, an average hearing loss of 55 to 60 decibels is usually brought to the level of those having a 30 to 35 decibel loss by the amplification of a hearing aid.<sup>2a</sup> Experience shows that his hearing performances only partially reflect this acoustic gain. A program of hearing reeducation is then superimposed, and additional hearing is regularly acquired thereby.<sup>3</sup> What, then, is to prevent a patient with a 30 to 35 decibel average loss from also acquiring hearing if given the same reeducation without a hearing aid? Patients with a 25 and those with a 20 decibel average loss have even greater possibilities. What is to prevent these from being carried to higher levels, and with greater ease, than any patient fitted with a hearing aid? In other words, the proposal to give reeducation of hearing without a hearing aid involves no more than the following: that the same hearing reeducation program regularly employed with benefit in cases in which a patient has first been brought up to a certain level by a hearing aid be given without a hearing aid in cases in which the patient is already at such a level. Since there appeared to be no obstacle to such a procedure, reeducation was given directly to the ears of a number of hard of hearing patients.

#### THE PATIENTS TREATED

The patients referred to in this report are the first 50 of a large number of consecutive, unselected persons applying for the relief of a troublesome and noticeable auditory impairment of more than several years' standing.

The duration of impairment ranged from several years to several decades—an average duration of twelve years, the age at which difficulty was first noticed, from 8 to 55 years—average 28, the age at

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<sup>3</sup> Silverman, S. R. Training for Optimum Use of Hearing Aids, *Laryngoscope* 54:29-36 (Jan.) 1944.

the time treatment was given, 20 to 57 years—average 40 All recalled that at some time in the past they had heard well

*Previous Therapy*—A few had never received any treatment, the rest had undergone one or more of the medical or surgical procedures commonly used in the treatment of defective hearing, all had consulted a physician about their ailment on more than one occasion Some had been fitted with a hearing aid, but in their estimation had not been benefited sufficiently to warrant wearing it, several wore a hearing aid on certain occasions, a few wore one regularly

*Progressive Character of Hearing Impairment*—In every case the hearing had become poorer since the onset In some the deterioration was gradual, in most it occurred in a steplike fashion every few years Several who thought they had maintained a certain level revealed a progressively narrowed circle of activity instead

*Degree of Impairment*—In order to demonstrate the extent and the nature of the improvement and the types and degrees of hearing loss which can be benefited, the degree of impairment was carefully determined and indicated in several ways

(a) By response to pure tones The threshold was obtained on several successive days with a standard audiometer in a room with a background level of noise of 10 decibels, the lowest threshold obtained was selected The average of the decibel losses from frequency 128 to 8192, inclusive, was called the "hearing loss" With the exception of 5 cases of unilateral impairment, the smallest average hearing loss in the series was 20 decibels in the better ear, the greatest, 90 decibels

(b) By disability This evolved into the replies of patient (and relative) to a questionnaire calling for the amount of difficulty experienced in a number of situations In addition, a single word descriptive of the over-all hearing status was recorded The situations selected were those which appeared most frequently in the histories, those volunteered most frequently by patient and relative, and those in which people are particularly anxious to hear properly Such a disability questionnaire automatically becomes a unique test of the impairment, for in the hard of hearing there is (as shown in figure 1) an unusual variation of disability in these different situations, a variation governed by factors other than the acoustic impact of sounds reaching the peripheral organ Standard hearing tests, though useful in many other ways, are unable to demonstrate this variation, for they indicate the disability in only one situation—the one in which they are performed—and may on that account grossly misrepresent the patient's performances in other situations or fail to depict many of his difficulties, his regression or his progress The questionnaire has these additional advantages It is a cross section of countless observations made under a variety of con-

ditions, its recording is practically free of a human element or a margin of error, it is actually the standard used by the patient and those about him for judging acuity of hearing and so becomes the most critical (and eventually the final) test of the merits of a hearing therapy or a hearing aid. The degree of hearing disability expressed by the patients in this series was in most instances that shown in figure 1.

(c) By the use of the term "hard of hearing," "*hard* of hearing" (*Schwerhörigkeit, du dur d'oreille*) expresses difficulty in hearing, as opposed to failure to hear. The difficulty is in interpreting what is heard, and coincides with the invasion of tones of the conversational speech area.

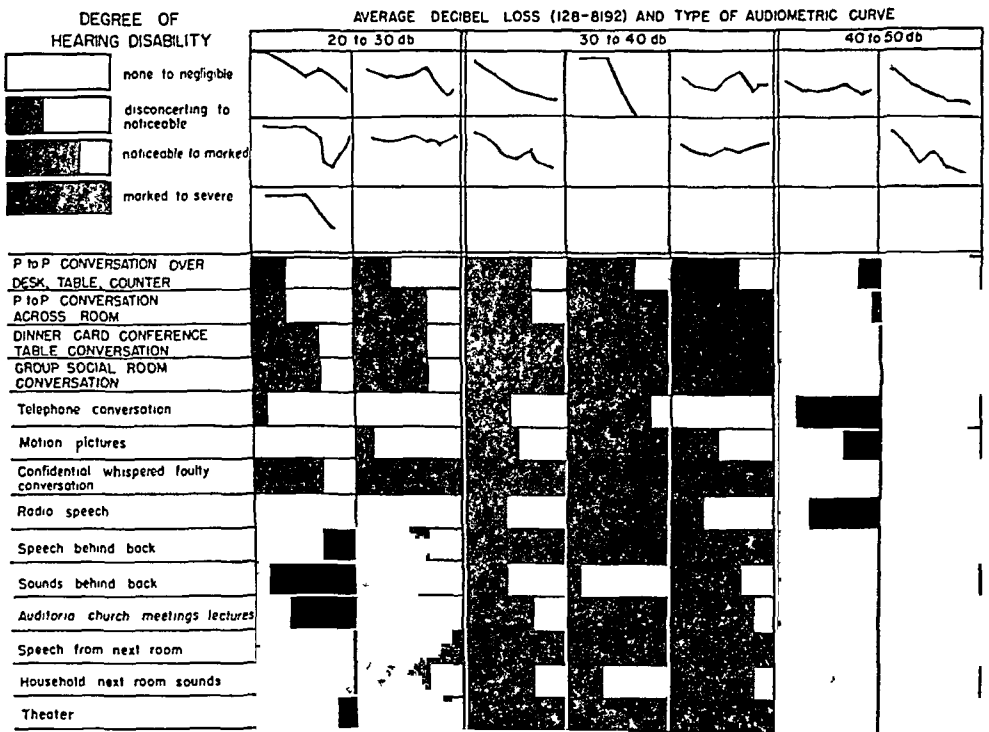


Fig 1—A composite picture of the degree of hearing disability noted in various situations by 200 hard of hearing patients with an average loss of 20 to 50 decibels in the better ear. The picture is a composite of replies to a questionnaire. Very hard of hearing persons fall in the 30 to 40 decibel group.

of the better ear. This is an abrupt change, the only change—from a state of no disability to one of awareness or evidence of disability, from no desire for assistance to the need and seeking of assistance—that occurs in all the grades of subnormal hearing. The audiometer cannot always be depended on to portray the degree of hearing disability, but it, too, indicates that there is a clearcut boundary of the hard of hearing state and serves to locate it acoustically (close to 20 decibels), for almost all persons with a 20 decibel average loss in the better ear have a noticeable difficulty of hearing and seek relief for it, whereas

those requiring less than 20 decibels of intensity rarely realize or show that they have a defect of hearing. There appear then to be only two well defined classes of patients with impaired hearing—those who are in difficulty and those who are not, and since the term “hard of hearing” denotes a noticeable or a troublesome degree of impairment, it is, when properly used, the least arbitrary way of separating the two. All the patients in this series were hard of hearing, and that term applied to them, since theirs was a troublesome degree of hearing impairment and (with the exception of 5 who had unilateral impairment) they showed a hearing loss of 20 decibels or more in the better ear.

*Pattern of the Impairment*—As indicated in the air conduction audiograms in figures 2 and 3, four types of graph were most frequently encountered: (1) the “flat” loss, (2) the “flat” loss with a peak at 2048, (3) the abrupt high tone loss and (4) the gradual high tone loss.

*Types of Peripheral Lesion*—From the audiograms (bone and air), the patient’s statement of the effect of noise and the telephone on his ability to understand speech, the appearance and motility of the tympanic membrane and from functional testing of the eustachian tube, the hearing impairment appeared in most instances to have been caused by one of the following five types of peripheral lesion: (1) chronic suppuration of the middle ear (healed and unhealed), (2) chronic catarrh of the middle ear or the eustachian tube, (3) ankylosis of the stapes, (4) involvement of the first turn of the cochlea (abrupt high tone loss) and (5) involvement of the auditory nerve (gradual high tone loss). Although the suppurative type predominated, each of these five types had a fairly equal representation. In any event individual modifications in the therapy were dictated primarily by the amount of hearing loss and not by the site or the character of the lesion.

Barring those with a meager knowledge of English (these were not accepted), the 50 patients whose treatment is reported appear to represent sufficiently well the next 50 patients who will consult an otologist, an outpatient department and a hearing aid company for a long-standing and troublesome disorder of hearing.

#### THE THERAPY

A normal hearing ear can distinguish 1,500 different pitches and 325 degrees of loudness—a third of a million tones in all. The usefulness of such an ear lies more in this ability to detect small differences in the sound patterns it hears than in its ability to hear faint or distant sounds, for it is the individuality of the sounds heard by the normal ear that furnishes it reliable information with little effort, and constitutes the stimulus which maintains its low hearing threshold. In

TABLE 1—The Results of Auditory Reeducation of Patients 1 to 29 Without the Use of Hearing Aids

Patient	Initials	Sex	Age	Dis- ability	Num- ber of Years at Onset of Hear- ing	Impression of Type of Peripheral Lesion (Better Ear)	Average Db Loss (128 Sigs) Better Ear	Degree of Hearing Disability Before Hearing Reeducation †	Degree of Hearing Disability (Months, Years) After Completion of Hearing Reeducation †	Consonant Articulation Test				
										T, m, n, t, u, s, etc. Pressure, Etc	Dis- tance in Feet	Words and/or Sylla- bles	Errors Before Hear- ing Reedu- cation	
														Before
1	S S	M	46	42	4	Otitis media, ad- hesive	20	Noticeable	9 mo	None	25	50	22	6
2	M G	F	38	35	3	First turn coch	20	Noticeable	9 mo	None	25	50	18	3
3	E C	M	31	26	5	First turn coch	20	Noticeable	9 mo	None	25	110	20	8
4	G G	M	48	48	5	First turn coch	21	Noticeable	4 mo	None	25	50	15	4
5	L C	F	48	43	5	OMCO	21	Marked	8 mo	None	25	110	39	12
6	I S	M	41	37	4	Dry perforation	23	Noticeable	5 mo	None	25	150	40	15
7	R R	F	32	29	3	Nerve deafness	24	Noticeable	1 yr	Occas	15	60	33	5
8	S B	F	35	25	10	Otosclerosis	25	Noticeable	6 mo	Occas	15	60	39	9
9	L G	F	37	20	17	OMPC, healed	26	Severe	9 mo	None	15	60	44	15
10	S S	M	29	16	13	OMCC	27	Marked	2 yr	Occas	15	60	40	10
11	L J	F	42	30	12	OMCC	28	Marked	3 yr	None	15	160	40	
12	F B	F	57	54	3	Cochlear	28	Noticeable	3 yr	None	15			
13	H L	F	22	16	6	Unhealed radical mastoidectomy	30	Marked	2 yr	Occas	15			
14*	A B	M	47	32	15	First turn coch	30	Noticeable	2 yr	Notice	15	60	13	7
15	M T	M	56	51	5	Nerve deafness	32	Noticeable	1 mo	None	15	60	31	7
16	B E	M	32	26	6	Otosclerosis	32	Noticeable	3 yr	None	15	60	50	21
17	R M	F	23	18	5	OMCO	32	Marked	6 mo	None	15	60	44	26
18*	P G	M	31	21	10	OMPC, healed	33	Marked	2 yr	Notice	15	60	21	5
19	M M	F	42	24	18	OMCO	34	Marked	3 yr	Occas	15	60	21	5
20*	M H	M	38	28	10	Otosclerosis	34	Noticeable	3 yr	Occas	15	150	67	14
21	S M	M	57	27	25	Dry perforation	35	Marked	1 yr	Notice	15	60	11	11
22	B K	F	24	12	12	OMPC, healed	36	Marked	3 yr	Occas	15	60	51	18
23*	H L	M	48	41	7	Nerve deafness	36	Marked	6 mo	Occas	15	60	36	17
24	H G	M	33	18	15	Dry perforation	41	Marked	3 yr	Occas	15	60		
25	A U	M	53	30	23	Otitis media, progressive	42	Severe	9 mo	Occas	15	60	46	21
26*	S F	F	29	23	6	Otosclerosis	46	Severe	6 mo	Marked	15	60		
27	F W	F	51	45	6	First turn coch	51	Severe	3 mo	Occas	5	30	35	20
28	A F	M	51	8	43	OMPC, healed	52	Marked	6 mo	Occas	15	60	32	13
29*	D O	F	40	22	27	Undetermined	60	Severe	6 mo	Notice				

\* Result was unsatisfactory

† Patient's (relatives') description

OMCC indicates chronic catarrhal otitis media, OMPC, chronic purulent otitis media

an impaired ear many tones by which sounds could be identified are missing, and much of the difficulty which such an ear experiences arises not from an inability to hear sounds but from the fact that too many sounds appear to be alike. Not only will "mare" sound like "bear," "hub" like "cup," "teeth" like "feet," but a bell may sound like a cough, a voice like someone rapping on a door, a whistle like china.

In the hard of hearing state one observes, then, an appreciable amount of hearing power which is of little or no use to the patient because with it he is unable to appreciate the difference between many sounds or he mistakes one sound for another. As a result, there is an increasing tendency to disregard such sounds, a raised threshold of response to them and for all practical purposes a loss of this much hearing power. In proportion to its amount, the latter makes for greater difficulty of recognition of sounds which up to now were plainly heard, and so on.

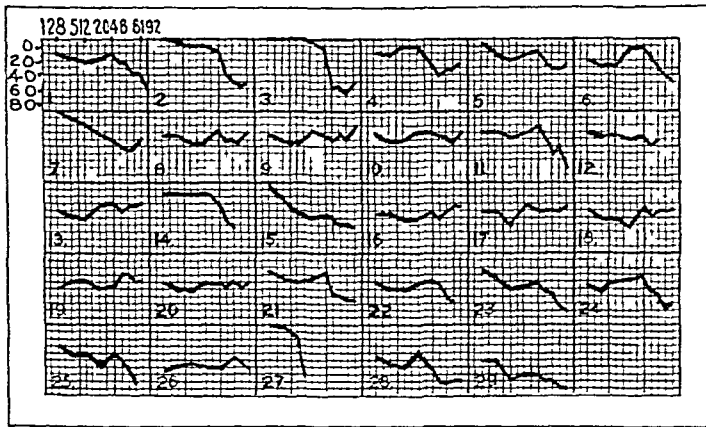


Fig 2—Audiograms of the better ears of patients 1 to 29

If this process is to be reversed, if that area of the hearing range which is not directly affected by the pathologic changes occurring in the ear is to remain available to the patient, it becomes apparent from the foregoing statement that as many as possible of the sounds which fall in this area be told apart and correctly interpreted by him. Interpretation of sounds and discrimination of sounds are therefore important features of reeducation of hearing, and since speech is the most important and most frequently heard of the day's sounds, speech is the principle vehicle employed and its interpretation one of the first steps in the therapy.

*Improved Interpretation and Hearing of Speech*—Seated face to face with the patient at a distance at which a conversational tone of voice can just be comfortably heard by him, the speaker delivers simple statements concerning a single topic at conversational loudness and prevents visual recognition of them by holding a 5 by 8 inch (12.5 by

TABLE 2.—The Results of Auditory Reeducation of Patients 30 to 43 and 48 to 50 Without the Use of Hearing Aids

Patient Initials	Sex	Age at Onset of Deafness	Number of Years of Hearing	Impression of Type of Peripheral Lesion	Average Db Loss (128-8192)	Hearing Disability (D)†				Consonant Articulation Test			
						Before Hearing Reeducation		After Hearing Reeducation		Dis tance and/or in Syl la bles	Words Hear ing Redu cation	Errors Before Hear ing Redu cation	
						Room Sounds	Interpretative Conversation	Interpretative Whisper	Localization of Sounds				
30				Otitis media, ad hesive	45		D	D		Const	None	None	15
31				First turn coch	29		D	D		Mdrt	None	None	15
32				OMCO	38	D	D	D		Const	Const	None	60
33				OMPC	50	D	D	D		Mdrt	Occas	None	60
34				Otosclerosis	34	D	D	D		Mdrt	Occas	None	60
35				OMCO	30	D	D	D		Mdrt	None	None	60
36				Healed radical mastoidectomy	53		D	D		None	None	None	60
37				Otitis media, progressive	61	D	D	D		None	None	None	60
38				Healed radical mastoidectomy	55	D	D	D		Occas	None	None	60
* Patients 39 43 Patients with Normal Hearing in Better Ear Poorer Ear Treated)													
39	M	A	24	First turn coch	28	D	D	D		Const	None	None	15
40	J	S	16	Dry perforation	24	D	D	D		Const	None	None	15
41	F	L	41	Cochlear	39	D	D	D		Const	None	None	15
42	H	R	38	Nerve deafness	32	D	D	D		Const	None	None	15
43	L	R	3	OMPC	55	D	D	D		None	None	None	15
† Patients 44 50 Patients with Impairment of Hearing in Both Ears Better Ear Treated)													
44	F	W	18	Nerve deafness	75								
45	J	B	32	Nerve deafness	75								
46	R	Z	18	Nerve deafness	75								
47	E	A	28	Nerve deafness	75								
48†	R	P	25	Otitis media, progressive	50								
49†	E	G	15	Otosclerosis	48								
50†	E	L	30	Cochlear	37								

\* Patients 30 to 38 are patients 1, 4, 5, 6, 8, 11, 24, 25 and 28 of table 1 seeking treatment for the other, poorer ear

† The result was unsatisfactory

‡ Patient's statements

20 cm ) card at an angle of 45 degrees in front of his mouth. The patient is asked to repeat whatever he hears, and if correct he is so informed. If not, the card is removed and the sentence repeated. This is continued for several minutes. The patient and relative seldom fail to express surprise at what they consider a good performance, for the distance is usually two, three or even five times that which was believed to be the limit for his hearing of conversation. This serves to illustrate how little of his hearing power the hard of hearing person utilizes.

When possible, this procedure is repeated the following day, and daily thereafter, and additional improvement is noted each time. The reason for this improvement is that having been given the opportunity to interpret and identify them, the patient discovers that many of the vague, incomplete or unfamiliar speech patterns received become adequate and take on full meaning. On this basis alone his understanding of speech can be improved, for there are audible features of speech

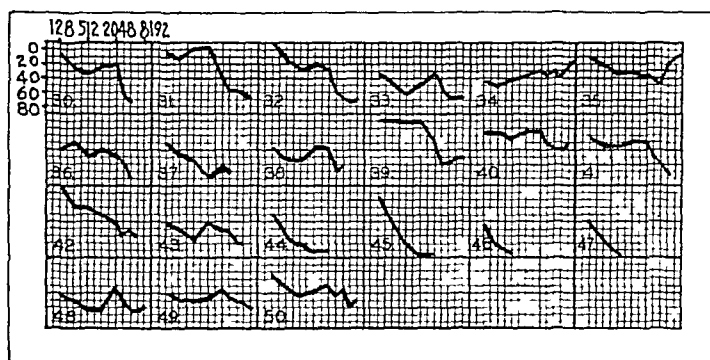


Fig 3—Audiograms of the poorer ears of patients 30 to 43 and the better ears of patients 44 to 50

patterns, beside pitch and loudness, which make this possible—accent, rhythm, inflection and duration. For purposes of comparison and contrast, complete speech patterns are also provided by having the patient listen to speech through a speaking tube.

Further improvement of the understanding of speech is subsequently conferred by correcting misinterpreted speech. The latter rests principally with a misinterpretation of a number of the individual speech elements or sounds (the consonants and the vowels). These are corrected in the following way. Monosyllabic word lists of a length sufficient to include all the speech sounds of English are delivered in the manner just described for conversation. The replies disclose that certain speech sounds, particularly the consonants, are regularly mistaken for others by the patient. Speech sounds mistaken one for the other are then incorporated in individually prepared word lists in a manner calculated to set off their differences—in pitch, loudness, impulse, duration. For example, if the sounds “n,” “l” and “d” appear



interchangeably in the patient's replies, they can be arranged in this fashion

die, lie, nigh  
low, no, dough  
an, Al, add  
day, nay, lay

and so on. The routine described for the interpretation of conversation, with its corroboration or correction, is then followed. In calling off each row, one word at a time, the patient is forced to depend solely for the correctness of his reply on any small differences which his ear is able to detect in the patterns of "n," "l" and "d." Even though these differences may never become as striking as they are to a normal hearing ear, the patient is generally able in the course of time to discriminate between, and correctly interpret by ear, most or all of the misinterpreted speech sounds. Each one so reclaimed naturally becomes the source of a certain amount of improvement in the understanding of speech throughout the day.

When a satisfactory degree of facility in understanding is attained at the distance originally selected, it will be found that the intervening distance may now be increased, the voice lowered or the context made more difficult, with little effect on the caliber of the performance. Eventually speech is presented to the patient in what had been for him more difficult situations (fig. 1). In this way, the understandable speech acquired as described is made to act as the pacemaker in the regaining of discrimination of sounds and the lowering of the threshold of hearing for speech—thus reversing the process whereby poor discrimination of sounds and a raised threshold of response to sound, acting reciprocally, had created increasing difficulties in hearing. Many examples of this important relation of sound interpretation to hearing threshold can be given. One will suffice, the finding of Macfarlan<sup>4</sup> that words spoken in sentences are picked up at a 10 to 20 decibel lower level than are single words.

When reeducation is given to the poorer ear, the auditory canal of the better ear should be closed. The patient's finger is the most practical means of accomplishing this.

*Improved Hearing for Sounds Other Than Speech*—Speech occupies a large and exceptionally sensitive area of the human hearing range, and in the course of acquiring improved hearing for speech many thousands of tones become audible. The acquisition of such tones fills in gaps in many sound patterns which are heard throughout the day and so enables the patient to recognize these and respond to them. Thus, improved hearing for many sounds other than speech follows

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<sup>4</sup> Macfarlan, D. Speech Hearing Tests, *Laryngoscope* 55 71-115 (Feb) 1945

automatically in the wake of better heard speech. On the other hand, a number of sounds still remain unheard and in all probability will not be acquired unless they are "gone in for" individually. Of these, the most useful or most desired by the patient are selected first. They are for the most part sounds of bells, buzzers, whistles and other sounds commonly used as signals, ticking of the clock, rapping on doors, kitchen and household sounds, sounds encountered by the patient in his office, shop or occupation.

The principles involved in conferring hearing for sounds of this sort are no different from those described for improving the hearing of speech. (1) Unrecognized, vaguely familiar sounds are poorly heard sounds, and (2) the threshold of response is higher with these than with readily recognized sounds of a like intensity. The patient is therefore given many opportunities of identifying at close range the inadequate sound pattern he receives with the object that produces it. If necessary, this is contrasted with similar sounding objects. As he becomes familiar with its sound and demonstrates his ability to recognize it, it is presented to him from increasingly greater distances. Eventually the sound is produced unexpectedly from time to time, and then if he is able to identify it regularly, this is taken as adequate proof that his threshold of hearing has indeed been lowered for it and he will be able to hear it henceforth without further assistance. It is not difficult to confer hearing for sounds of this type, for there are not many of them that the patient needs greatly or desires to have, and they do not have to be identified as accurately as the speech sounds, in order to be heard well.

*Comment*—Sound is the only therapeutic agent employed, sound in a number of forms, at various levels of loudness or distances and in various situations. The principal vehicle used is speech (conversation, sentences, words, syllables), delivered directly from mouth to ear. As an alternate, artificially produced speech (recordings, sound track, etc.) appears to have little to offer when normally delivered speech is available, it was eventually discarded. Its sound patterns bear the same relation to purely air-borne speech that a patois or provincial speech bears to an official language—something to be learned and then unlearned before speech as ordinarily received can be understood. However, no source or form of sound, complex or pure, is omitted if judged useful for a patient. The approach is the same for all patients, but individual variations are the rule. None of the work is done in groups. The interval between visits is gradually increased, but treatment continues as long as progress is reported or observed, or until a level commensurate with the patient's needs is reached. This generally appears by the end of three months, although several weeks of care is found to be adequate in some cases, while six months of supervision may be necessary or profitable in others.

Like the fitting of a hearing aid, the teaching of lip (speech) reading has come to be regarded as an essential part of all hearing rehabilitation programs. Experiences with lip reading in this series do not bear this out but lead to the following conclusions. In the patient whose hearing is severely impaired vision is indispensable for satisfactory understanding of speech and in many of these reeducation must be supplemented by the teaching of lip reading. When hearing reeducation is given to patients with less than a 50 decibel loss, no benefit is derived from the teaching of lip reading, on the contrary it impedes or detracts from the central purpose of the program, namely, that the patient's attention be directed to auditory stimuli and away from the visual, which he had been depending on more and more. On that account the formal teaching of lip reading is deliberately omitted in all cases in which hearing is not severely impaired. It is felt that this move affects the outcome favorably.

The therapy described does not differ in principle from the hearing reeducation programs usually suggested or employed for augmenting the performance of hearing aids, but it does differ from them in the following respects. Its duration and scope are not predetermined, it avoids the teaching of lip reading, it places as much importance on improved hearing of sounds as it does on improved understanding of speech, it devotes special attention to hearing in various situations, and is given directly to the human ear. The last has great significance, for the ear has these advantages over a hearing aid: (a) a constant reference level, available at all times and in all situations, (b) a wider range of comfortable hearing and a wider frequency range, and (c) binaural hearing in most cases. Furthermore, the patient has a greater stake and more to gain in learning to overcome the shortcomings of his own ear rather than those of the hearing aid, and he is free of the social, economic and psychologic drawbacks connected with an instrument. It might be well to add that the program was administered personally by an otologist.

#### THE RESULTS

*Reporting of Results*—A comparison of the hearing disability of most recent date (as stated by patient and relative on a duplicate of the original disability questionnaire) and the hearing disability at the start of treatment was taken to be the best indication of the improvement brought about by the treatment. This is shown in tables 1 and 2 and figures 1 and 4.

When the series was started, no change was expected or demanded of the audiogram, but the rapid acquisition of faint sounds called for audiometric retesting. Audiograms were therefore taken from time to time. Surprisingly large pure tone gains occurred in some of the cases but since there appeared to be no constant relation between these

and the clinical gains, they are not included in this report. Some of the largest and most unusual of the clinical gains in the series were made in the face of an unchanged audiogram. This should occasion no surprise, for the threshold is much lower, as a rule, for the complex sounds of daily life than for pure tones. For example, in comparing the hearing loss for numbers heard over the Western Electric 4A phonograph-audiometer with that shown by the 2A pitch audiometer, Macfarlan<sup>4</sup> pointed out that the numbers were generally heard at a very much fainter level than were the pure tones.

Word list scores were recorded before and after treatment in most of the cases and are reported here (tables 1 and 2). As with all other single tests of hearing, it is difficult to formulate a quantitative relationship between them and the everyday hearing performances of the patient. However, since word list scores are currently used as a measure of the gain derived from a hearing aid, they provide a means for comparing such gains with those derived from hearing reeducation.

The more interesting of the clinical gains were recorded in the form of "progress notes" kept in each case. These are also reported, and an explanation is offered to account for them.

*The Results*—Tables 1 and 2 and figures 2 and 3 give the results.

*Progress Notes*—These notes concerned hearing gains about which the patient volunteered information from time to time. These gains consisted of an improved understanding of speech and a newly acquired hearing for sounds other than speech. The latter type of gain constitutes the most interesting and significant feature of this report, because the sounds were such as had not been heard in many years, and the hearing of them was acquired without special training. They were of the following sorts: room, household, occupational and office sounds, sounds of bells, buzzers, door rapping, chimes, clocks, water running in basins and tubs, dishes, ornaments, etc., sounds from an adjacent room, sounds coming through closed doors, sounds (voices and radio) coming through walls and floors from an adjacent apartment, sounds of rain, distant thunder or airplanes, and the hum of street sounds. In some cases the hearing of such sounds was acquired in a few days, in others, in a few weeks, in others, after a few months.

*Analysis of Results*—The "satisfactory" hearing levels and the "occasional" disabilities referred to in the following paragraphs are indicated in detail in figure 4.

(a) Of 46 consecutive, unselected patients with all types and durations of hearing loss who were treated without a hearing aid, only 9 (1 of 5) continued to have either a disabling or a noticeable degree of impairment. The remaining 37 (4 of 5) showed either no disability (21) or only occasional evidence of it (16).

(b) The 12 hard of hearing patients with a 20 to 30 decibel loss in the better ear all attained a satisfactory hearing level (no hearing disability in 9, only occasional evidence of disability in 3), yet there are few instances or situations (fig 5) in which persons in this group of the hard of hearing are able to tolerate, or benefit by, a hearing aid

(c) Of the 21 hard of hearing patients with a 20 to 35 decibel loss in the better ear, 18 (6 of 7) reached a satisfactory hearing level (no hearing disability in 12, only occasional disability in 6), only 3 (1 of 7) failed to reach such a level This group represents 60 per cent of the patients of this series there is every reason to believe that

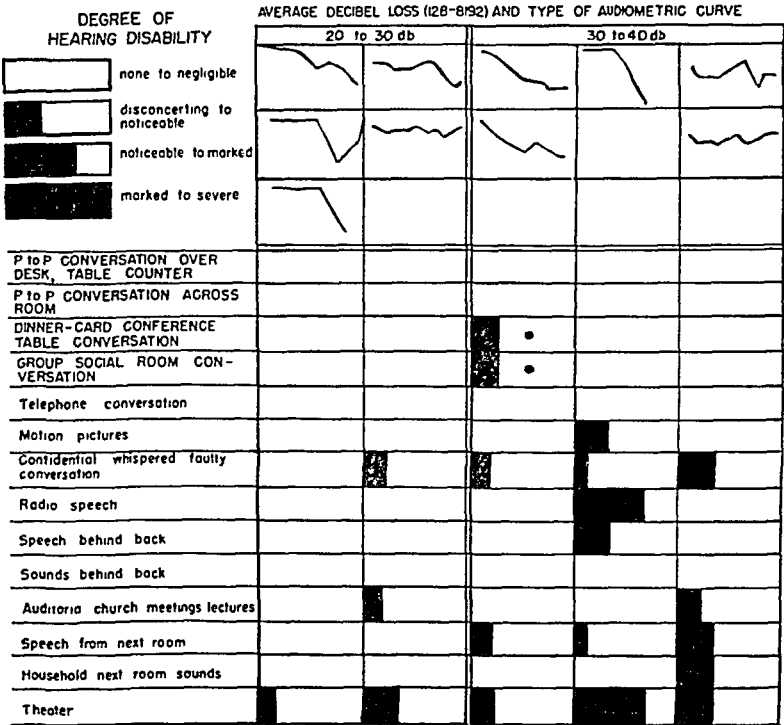


Fig 4—A composite picture of the level of hearing attained through auditory reeducation without the use of hearing aids by 21 of 26 hard of hearing patients with an average loss of 20 to 40 decibels in the better ear The picture is a composite of replies to a questionnaire The black dots indicate that there was disability in noisy surroundings only

more than half the patients who seek help for a hearing impairment belong in it Yet (as shown in figure 5) this large group is, with few exceptions, acoustically unsuited for hearing aids—not tolerating them or deriving no benefit from them, either in all or in the most needed situations Corroborating this finding is one of the recommendations of the Committee on Hearing Conservation of the American Academy of Ophthalmology and Otolaryngology<sup>5</sup> “A hearing aid is

5 Conservation of Hearing The Otologist's Role in the Fitting of Hearing Aids Committee on the Conservation of Hearing, Tr Am Acad Ophth 50 215-217 (July-Aug ) 1946

indicated when the threshold of hearing of the better ear is impaired across the speech range by 35 decibels or more” In addition Carhart and Thompson<sup>6</sup> stated that “the person must have a degree of loss which lies within the range where hearing aids give promise of useful compensation

Generally speaking, patients whose 512-2048 c p s averages for the better ear lie between 45 and 75 decibels are most effectively helped [by a hearing aid] ”

(d) Of the 11 hard of hearing patients with a 35 to 52 decibel loss in the better ear, 6 reached a satisfactory level of hearing (the same level as shown for the 30 to 40 decibel group in figure 4), report-

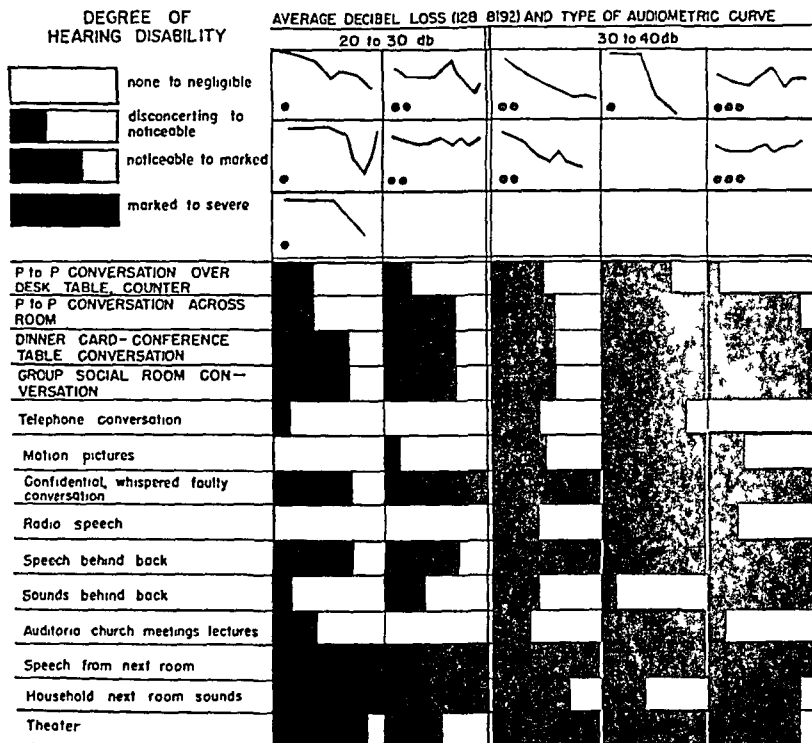


Fig 5—A composite picture of the level of hearing attained through hearing aids by 100 hard of hearing patients with an average loss of 20 to 40 decibels in the better ear. One black dot in an audiogram means that the patient was unable to tolerate a hearing aid, two black dots, that the patient found a hearing aid useful or tolerable only in such places as auditoriums, three black dots, that the hearing aid was useful only in auditoriums, moving picture and other theaters and for interviews

ing only occasional disability, 5 failed to improve sufficiently. Patients in this group are for the most part acoustically suited for a hearing aid and in that respect could be fitted, yet many of these are unsuited because of their station, calling or temperament

(e) Reeducation was directed to the poorer ear only when the patient complained of one or more of the following disabilities peculiar

<sup>6</sup> Carhart, R, and Thompson, E. A. The Fitting of Hearing Aids, *Tr Am Acad Ophth* 51-354-361 (March-April) 1947

to monaural hearing turning the better ear toward conversation or whispered speech directed to the poorer ear, inability to hear voices and room sounds when lying on the better ear, and difficulty in localizing the source of sounds In 14 cases the therapy was directed to the poorer ear (In 9 the better ear was hard of hearing, in 5 the better ear was normal) All the patients reached a satisfactory level of hearing (table 2) no disability in 11, only occasional disability, and then with confidential or whispered speech, in 4

(f) Two thirds of the patients complained of discomfort in the ears (tinnitus, pressure or itching) There were 22 with such symptoms who were brought to a satisfactory hearing level, only 2 of these failed to report a diminution of symptoms (in the poorer ear in both), whereas 16 became symptom free On the other hand, there were 5 who did not reach a satisfactory hearing level, none of these became symptom free, and 3 failed to note any diminution of the symptoms

(g) To date, with more than three fourths of the patients responding to periodic reexamination, no patient who reached a satisfactory level has reported a regression of hearing and 5 have maintained their improvement for three years A number of patients reported transient regressions These seldom lasted more than a day and were followed by an abrupt return to a satisfactory level They were invariably the result of mental fatigue or preoccupation and were regularly associated with some trying or worrisome incident In a number of patients further gains were made after completion of the reeducation program

#### INTERPRETATION OF THE HEARING GAINS

In a large group of unselected hard of hearing patients, hearing gains were obtained by directing therapy to the cerebrum without the use of pharmacologic, physical, mechanical or surgical measures This can be explained in one or the other of two ways

1 The entire amount of the disability, or the progressive increase therein, which a hard of hearing patient exhibits (by poor interpretation and response to daily sounds or those of hearing tests) is accounted for by pathologic change occurring in the peripheral hearing mechanism, and the hearing gains reported merely represent an increased use which the brain has been taught to extract from an impaired ear This without question accounts for a part of the gains—small, slowly acquired gains—but it cannot be reconciled with sudden or appreciable gains, newly acquired hearing of sounds of a loudness well below the threshold of the initial audiogram (see under "Progress Notes," page 523) or extraordinary gains shown by the unused (poorer) ear The following explanation of these is far more satisfactory

2 Only part of a hearing disability (exhibited by test or otherwise) can be accounted for by peripheral pathologic change, the remainder,

a superimposed nonpathologic hearing disability of central origin, the result of circumstances arising from the hard of hearing state itself, is the principal source of the gains reported. There is a normal cerebral diminution of hearing in narcosis, fatigue, preoccupation and other temporary states. The hard of hearing state (with its impairment of the keenest of the senses, its faulty interpretation of sounds and breakdown of the chief means of communication) is a state of continuous uncertainty and ineffectual effort. It would be surprising to find, after many years of it, no change in attitude toward or response to sound, no diminution in the extent to which sound is employed, and no progressive cerebral diminution of acuity of hearing, over and above that due to peripheral change. The poorer ear, an ear whose situation should make it unusually susceptible to changes such as these, appeared to offer a good opportunity to demonstrate the role which circumstances alone play in defective hearing. The striking gains made by these ears through hearing reeducation lend strong support to the explanation here offered of the source of the gains reported. There is a great temptation to look on all losses of hearing, especially those indicated by tests of hearing, as being derived from a single source only—pathologic change—and not likely to be altered by anything else. It must be remembered that in tests of hearing, as well as in daily hearing, both central and peripheral hearing are represented and are being tested simultaneously and must each be taken into account in the interpretation of all losses (or gains), particularly in cases of long standing. The interpretation here offered of the source of the gains obtained makes only one demand, a not unreasonable one—that the familiar types of pathologic change present in the ears of hard of hearing persons be not considered to offer quite as much acoustic impedance and to be as progressive in character as otologists have been inclined to believe. The least that can be said for such a concept is that it can lead to attempts to free a portion of hearing losses which might otherwise remain untapped.

#### INTERPRETATION OF THE RELIEF OF AURAL SYMPTOMS (TINNITUS, ITCHING, FULNESS)

When a satisfactory level of hearing was reached, symptoms disappeared because 1. Newly acquired outside sounds were masking the physiologic body sounds so often heard when hearing is impaired (Saltzman and Ersner<sup>7</sup> have since observed that a hearing aid often relieved tinnitus, and they have offered the same explanation.) 2. The tension and fatigue of the hard of hearing state disappeared and with them the tinnitus, itching, fulness and pressure which so often are a

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<sup>7</sup> Saltzman, M., and Ersner, M. S. A Hearing Aid for the Relief of Tinnitus Aurium, *Laryngoscope* 57 358-366 (May) 1947



part of fatigue and tension 3 With the diminution in hearing difficulties the patient became less "ear conscious" in general and thereby less conscious of symptoms arising in the ear

### CONCLUSIONS

Auditory reeducation is an effective therapeutic measure indicated in all degrees and patterns of hearing loss of long standing and in all situations in which an untroublesome level of hearing has not been, or is not likely to be, reached or maintained through other measures

Though generally thought to be a procedure which can be given only with a hearing aid, auditory reeducation may be given effectively with or without a hearing aid On the other hand, a hearing aid seldom provides a satisfactory level of hearing without auditory reeducation

As a rule, those with more than a 40 decibel average loss between the frequencies of 128 and 8192 cycles per second in the better ear require both hearing aid and hearing reeducation, but some patients with a loss as great as 50 decibels can be brought to a satisfactory level without a hearing aid

As a rule, those with less than a 40 decibel average loss between 128 and 8192 in the better ear can attain a satisfactory level of hearing through auditory reeducation without a hearing aid, but some require both hearing aid and hearing reeducation

Patients with a 20 to 35 decibel loss in the better ear can tolerate a hearing aid in very few situations in the course of the day On that account, they have in the past been forced to remain hard of hearing, although numerically they constitute an appreciable portion of the hard of hearing group When given auditory reeducation alone few of them fail to attain a satisfactory level of hearing

Hearing reeducation without a hearing aid is also indicated for the following persons 1 Those with a 35 to 50 decibel loss in the better ear who are acoustically suited, but whose station, calling or temperament makes them unsuited, for a hearing aid 2 Those unsuited for a hearing aid whose tinnitus or other aural symptoms are caused by the hearing loss itself 3 Those who have had a hearing aid fitted to their poorer ear because they were unable to tolerate a hearing aid in the better ear Such patients can attain a satisfactory level of hearing through auditory reeducation alone and thus are relieved of the necessity of resorting to a *gauche* procedure 4 Those who are well suited but prefer not to wear a hearing aid Unless they have more than a 50 decibel loss in the better ear, it would be justifiable to give them auditory reeducation first and decide later whether they have to wear a hearing device 5 Those, who through disuse of the poorer ear, exhibit one or more of the disabilities characteristic of monaural hearing

# IS IT POSSIBLE TO COVER THE FENESTRA NOV-OVALIS WITH SHRAPNELL'S MEMBRANE?

An Anatomic Study

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THE fenestration operation of today is the result of many successive efforts by otologists all over the world Sourdille<sup>1</sup> created the tympanomeatal plastic flap to seal the widened tympanum and to cover the fenestra Lempert<sup>2</sup> simplified this step and made the one stage technic at once a more practical and more desirable procedure than the many stage fenestration operation of Sourdille In Lempert's judgment the covering and sealing of the fenestra with Shrapnell's membrane were of prime importance in the surgical technic, and the success or failure of the operation hinged to a great extent on this In another paper<sup>3</sup> Lempert reported that osteogenesis occurred when the fenestra was covered with the meatal skin of the tympanomeatal membrane and that it did not occur when the fenestra was covered with Shrapnell's membrane He came to the conclusion, therefore, that Shrapnell's membrane discouraged osteogenetic closure when it covered the fenestra, because it does not adhere to or nourish the bony fenestral walls

Later, when describing the fenestra nov-ovalis operation, he explained that the fenestra was now placed over the surgical dome of the vestibule and anterior to its previous situation, over the prominence of the external semicircular canal Thus the fenestra nov-ovalis was placed anatomically closer to Shrapnell's membrane Lempert<sup>4</sup> stated

The anatomic relationship of position between the fenestra nov-ovalis and Shrapnell's membrane makes the covering of the fenestra with this membrane possible in every case

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1 Sourdille, M, cited by Duel, A B, and others Otosclerosis Resume of Literature from 1928-1935, Ann Otol, Rhin & Laryng **45** 169-281 (May) 1936, New Technique in Surgical Treatment of Severe and Progressive Otosclerosis, Bull New York Acad Med **13** 673-691 (Dec) 1937

2 Lempert, J Improvement of Hearing in Cases of Otosclerosis New, One Stage Surgical Technic, Arch Otolaryng **28** 42-97 (July) 1938

3 Lempert, J Endaural Fenestration of External Semicircular Canal for Restoration of Hearing in Cases of Otosclerosis Summary Report of One Hundred and Twenty Cases, Arch Otolaryng **31** 711-779 (May) 1940

4 Lempert, J Fenestra Nov-Ovalis New Oval Window for Improvement of Hearing in Cases of Otosclerosis, Arch Otolaryng **34** 880-912 (Nov) 1941

This interpretation of the role of Shrapnell's membrane has been questioned by several investigators. In the opinion of Fowler Jr,<sup>5</sup> Shambaugh<sup>6</sup> and Day<sup>7</sup> it is an anatomic impossibility in most instances for Shrapnell's membrane to reach the fenestra.

The problem of bony closure is one of the most troublesome in fenestration surgery, and one not well understood. For this reason it seems desirable to attempt to resolve disputed anatomic opinions in the hope that a better understanding of the problem will be achieved. These differences regarding the role of Shrapnell's membrane can be explored and demonstrated on operative material.

#### MATERIALS AND METHODS

The object of this experiment was to measure the distance from the short process of the malleus to the upper limit of Shrapnell's membrane and also that from the short process to the fenestra in a series of cases so as to determine whether or not Shrapnell's membrane could be made to cover the fenestra, and if so, how frequently.

The material used for this study was a series of 50 fresh cadavers on which the fenestration operation was performed. This operation was accomplished as completely and as carefully as if it had been done on the living. Special pains were taken to remove thoroughly the annulus tympanicus above and the pyramidal eminence and the posterior spine below. This procedure insured the greatest possible excursion of the tympanomeatal flap to cover the structures posterior to the tympanum. Before the operation was begun, a fine, sharp-pointed, round needle, the end of which was dipped in green india ink, was thrust through the uppermost portion of Shrapnell's membrane into the tympanum so that the superior surface of the needle could at all times be felt against the bony canal wall. The puncture was virtually at the point where Shrapnell's membrane and the meatal skin meet, and it made possible identification of Shrapnell's membrane in such a manner that when the flap was completed, the green-stained puncture could be seen clearly on both the external and the internal surface of the membrane.

The tympanomeatal flap was thoroughly freed. After the fenestra was made in the surgical dome of the vestibule, the flap was firmly placed, to its limit, over the structures posteriorly in order that it might enclose the widened tympanum and cover the fenestra and the bony structures behind it. Then a large caliber, round, sharp-pointed needle, the tip of which was dipped in black india ink, was thrust through the flap, immediately over the fenestra, so that the needle went directly into the vestibule.

When the flap was raised, the black puncture wound could be seen clearly on its external and internal surfaces. This puncture of the flap over the fenestra was done in each of the 50 cadaver operations. The entire tympanomeatal flap was

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5 Fowler, E. P., Jr. Closure of Operative Fenestrae in Labyrinth, *Arch Otolaryng* **34** 209-224 (Aug.) 1941.

6 Shambaugh, G. E., Jr., and Juers, A. L. Surgical Treatment of Otosclerosis. Preliminary Report on Improved Fenestration Technic, *Arch Otolaryng* **43** 549-567 (June) 1946.

7 Day, K. M. Appraisal of Fenestration Operation. Report of One Hundred Cases, *Arch Otolaryng* **44** 547-559 (Nov.) 1946.

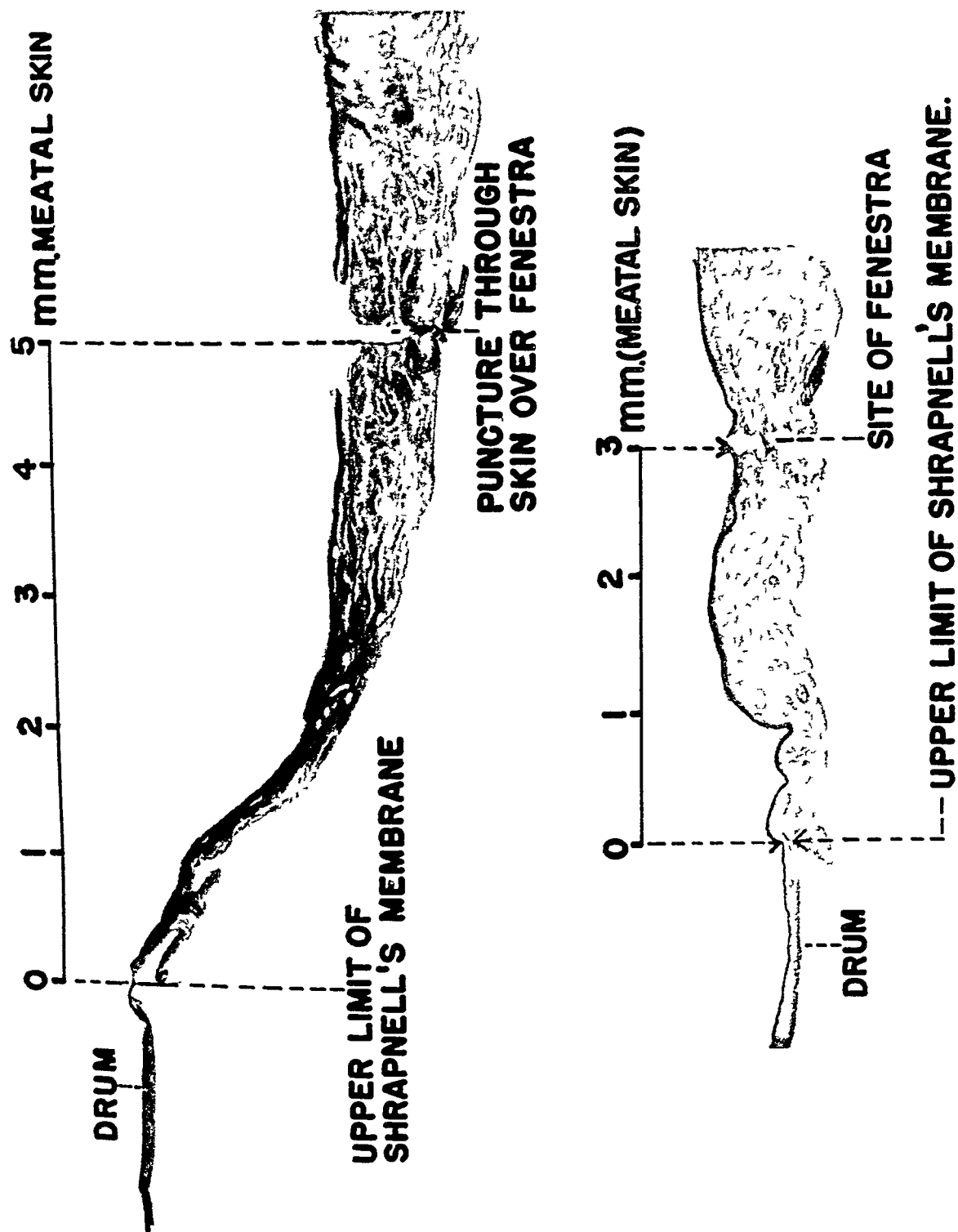
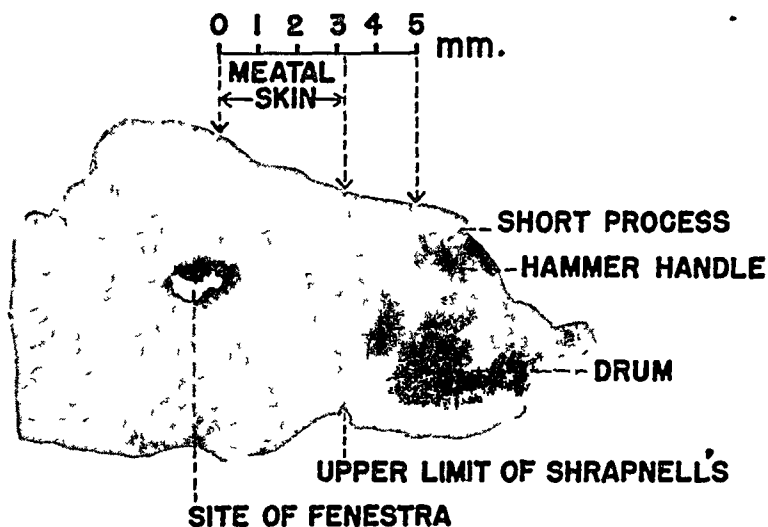
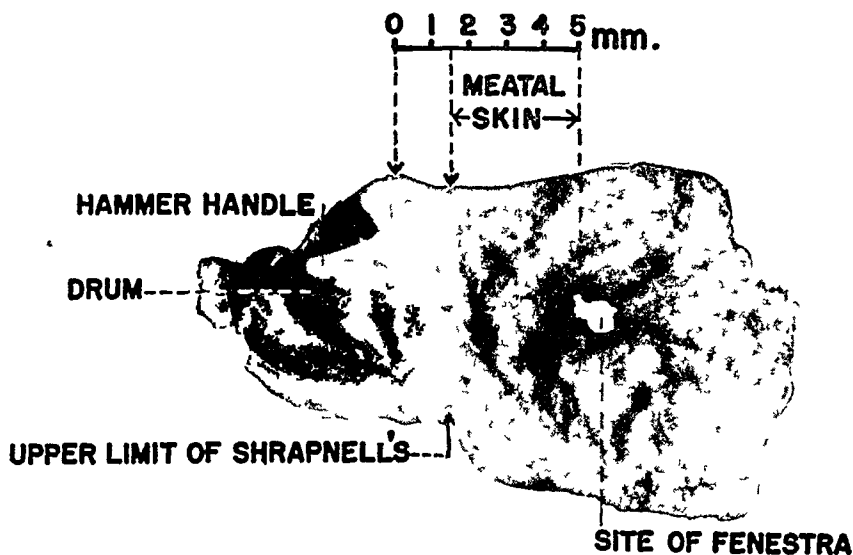


Fig 1—Histologic sections of 2 specimens showing the puncture wound leading into the fenestra. It may be noted that skin alone covers the fenestra. Shrapnell's membrane can be seen at a considerable distance from the fenestra. Over 15 flaps were sectioned, the findings were similar in each.



### EXTERNAL ASPECT



### INTERNAL ASPECT

Fig 2—Photographs of both surfaces of a tympanomeatal membrane in which the relative position of the short process, Shrapnell's membrane and the puncture wound covering the fenestra may be seen. The distance between the short process and the puncture over the fenestra is too great to permit Shrapnell's membrane to reach the fenestra. Thirty-five of the mastoid bones were large and pneumatic, 10 were moderate in size and diploic and 5 were small and sclerosed.

removed intact and carefully measured. In all cases a measurement was made from the short process of the malleus to the black puncture wound over the fenestra, and in 25 cases, from the short process to the green puncture wound (upper limit of Shrapnell's membrane). All measurements were made in millimeters with the aid of a  $\times 10$  optical loupe. This magnification made it possible to measure accurately to a half millimeter. Serial histologic sections of tympano-meatal membranes were made longitudinally through the puncture wound over the fenestra. In this manner the microscopic anatomy anterior and posterior to the puncture over the fenestra could be studied. Photographs of gross specimens were also made.

## OBSERVATIONS

The distance from the short process of the malleus to the puncture wound over the fenestra nov-ovalis was measured on 50 specimens, and

*Comparative Distance from the Short Process of the Malleus to the Upper Limit of Shrapnell's Membrane and from the Short Process to the Fenestra Nov-ovalis in Fenestrated Fresh Cadaver Specimens*

Distance in Mm	Short Process to Upper Limit of Shrapnell's Membrane, Cases	Short Process to Fenestra Nov Ovalis, Cases
15	10	
20	12	
25	3	
30		
35		
40		
45		
50		8
55		14
60		26
65+		2
Total	25	50
Average distance	1.8 mm	5.7 mm

the distance from the same starting point to the upper limit of Shrapnell's membrane on 25 of the same specimens. The results are shown in the table.

In 10 of the 25 specimens the distance from the short process of the malleus to the green puncture (upper limit of Shrapnell's membrane) was 15 mm, in 12 specimens, 20 mm, and in 3 specimens, 25 mm. No larger distances were observed. Gray's "Anatomy"<sup>8</sup> and others give the average height of Shrapnell's membrane as 1 to 2 mm. In 26 of the 50 specimens the distance from the short process of the malleus to the black puncture wound, indicating the site of the fenestra, was 6 mm, in 14 specimens, 55 mm, in 8 specimens, 50 mm, and in 2 specimens it was 65 mm or longer.

<sup>8</sup> Gray, H. Anatomy of the Human Body, ed 29, edited by T. B. Johnston and J. Whillis, New York, Longmans, Green & Co., 1946.

## SUMMARY

In 50 fenestration operations performed on fresh cadavers, there was no instance in which Shrapnell's membrane covered the fenestra. Since the distance between the upper limit of Shrapnell's membrane and the short process of the malleus is less than one third of the distance from the short process to the fenestra, it appears most improbable that Shrapnell's membrane can reach the fenestra.

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# HEMANGIOMA OF THE EAR AND MASTOID PROCESS

## Report of Two Cases

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MOORE,<sup>1</sup> in his "Textbook of Pathology," described hemangiomas and divided them into three classes hemartomatous hemangiomas, hemangioblastomas and sclerosing hemangiomas. In writing of the first group he described the pathogenesis as follows:

If, during development, a small mass of vascular tissue is misplaced or distorted, it may persist as a tumor. With the growth of the body the mass will become evident. Because of stagnation of blood, trauma, or other factors, new vessels form and enlarge the total mass more rapidly than the body as a whole.

He described two types of the hemartomatous hemangiomas: the capillary type, which is made up of numerous small capillaries separated by moderately cellular connective tissue, and the cavernous type, made up of widely dilated channels separated by trabeculae and most often seen in muscle, bone and liver. In the cases reviewed, 3 were reported to be of the last-mentioned type.<sup>2</sup>

The other two types Moore mentioned are rarely, if ever, seen in the ear. In the hemangioblastoma, a true benign neoplasm of endothelium, there is a conspicuous proliferation of endothelial cells, filling the vascular spaces and occasionally invading the surrounding tissue. In some hemartomatous hemangiomas, especially those of the skin and central nervous system, regressive changes may set in without detectable antecedents. The essential alterations in the development of a sclerosing hemangioma are fibrous isolation of capillary segments, accumulation of mononuclear cells filled with fat and deposits of hemosiderin.

## REVIEW OF THE LITERATURE

Hemangiomas of the external auditory canal, tympanic membrane, middle ear and mastoid are among the rare tumors found in the ear.

Presented before the Section on Otolaryngology of the College of Physicians of Philadelphia, Nov 19, 1947.

1 Moore, R. A. *A Textbook of Pathology: Pathologic Anatomy in Its Relation to the Causes, Pathogenesis, and Clinical Manifestations of Disease*, Philadelphia, W. B. Saunders Company, 1944.

2 (a) Politzer, A. *A Text-Book of the Diseases of the Ear for Students and Practitioners*, ed 5, London, Bailliere, Tindall & Cox, 1909, p 777. (b) Buck, A. H., cited by Politzer. (c) Mangabeira-Albernaz, P. *Brazil-med* (no 5) 53:120-126, 1939.



As a rule they are slow growing and benign, but they may become dangerous because of hemorrhage or pressure of the mass, causing erosion of the surrounding bone and injury to the adjacent structures. Malignant changes can take place in the tumor, but in only 1 case among those reviewed was there apparently any metastasis. This was a case of Bronzini's,<sup>3</sup> reported as an instance of "perithelioma," in which the patient refused operation until three years after he was first seen. A radical mastoidectomy was performed, followed by use of roentgen and radium radiation, but in six months after the operation the cervical nodes were involved, and the patient died about five years after he had been first seen by the physician. The pathologic reports given in the literature cannot be taken at their face value, as hemangioma, angiosarcoma, endothelioma, fibroangioma and certain other terms have been applied by various pathologists to growth probably of the same type of tissue.

*Course*—The development of hemangiomas of the ear is usually slow, and the condition may be present for years before the patient calls for medical aid. Occasionally, however, the progress may be very rapid, as is shown by the history in 2 of the cases reviewed, those of the only 2 patients in the series who were under 10 years of age. Both of these cases, because of the rapid progress of the neoplastic process, deserve more attention than will be given other individual cases. The youngest patient whose case was discussed (Calabresi<sup>4</sup>) was a 3 year old boy who four months before admission had found blood on his finger after inserting it into his external auditory canal. This condition was treated locally, but the patient soon complained of headache, insomnia and pain in the mastoid area. There was gradual facial paralysis, and a swelling developed over the mastoid area, but there was no fever. A radical mastoidectomy was performed and the tumor removed. Granulations were removed every three or four days afterward, with severe hemorrhage each time. In spite of everything, the mass developed rapidly, so that an enormous swelling appeared, making the ear seem to be on top of a tumor of the face. The child died one month after operation, the total time between the appearance of the first signs and death apparently having been only five months. There was no autopsy. The pathologist reported that the growth was fibromyxoangioendothelioma.

Sullivan<sup>5</sup> reported a case of a 5 year old girl who had apparently been in good health until about six weeks prior to admission, when

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3 Bronzini, A. Arch ital di otol 40 590-599, 1929

4 Calabresi, A. Osp maggiore 7 17-18, 1919

5 Sullivan, J. A. Hemangio-Endothelioma of Temporal Bone, Arch Otolaryng 20 61-67 (July) 1934

she complained of pain in the ear, which persisted and became progressively worse. Three days after the onset the mother noted a mass deep in the external auditory canal. This was removed by a physician, but after its removal it recurred and rapidly enlarged. Facial paralysis developed, and swelling and tenderness appeared over the side of the face. In spite of radical operation and roentgen therapy, the child died with a huge mass in the involved area, about two months after operation. The pathologic report was hemangioendothelioma. Autopsy showed that the mass had invaded the petrosa and had extended to the greater wing of the sphenoid bone anteriorly and the foramen magnum posteriorly. The tumor even had infiltrated downward into the neck and nasopharynx.

Politzer<sup>2a</sup> reported a fatal case of a girl of 12, with a history of illness of eighteen months. This case, with the 2 previously cited, and 5 others,<sup>6</sup> were the only instances reported of death due to the condition among the 55 cases covered by this paper (53 from the literature and 2 reported for the first time here). The ages of the 5 patients at the time of death varied from 21 to 50 years. The condition had been present in most of them for many years before they had consulted an otologist, and they lived up to ten years after such treatment as was possible was instituted.

*Age Incidence*—The age incidence of the entire series of patients at the time they were seen by the otologist was as follows: 2 in the first decade of life (the 2 who died so rapidly), 4 in the second, 7 in the third, 9 in the fourth, 9 in the fifth, 10 in the sixth, 5 in the seventh and 3 in the eighth. The age was not stated in 7 cases. The youngest of the group was 3 and the oldest 78 years of age. The women outnumbered the men 38 to 11, a ratio of more than 3 to 1, for the cases in which the sex was stated.

*Site of Origin*—The majority of the reports of cases,<sup>7</sup> including the present 2 cases, gave the location, or probable location, as the

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6 (a) Fraser, J. S. *J. Laryng. & Otol.* **27**: 200, 1912, **43**: 752, 1928, *Proc. Roy. Soc. Med. (Sect. Otol.)* **23**: 71-77, 1930. Bronzini<sup>3</sup> (b) Specht, F., and Volker. *Arch. f. Ohren-, Nasen- u. Kehlkopfh.* **120**: 93-104, 1929. (c) Irgens, E. R. Hemangioma of Skull Involving Right, Petrous and Occipital Bones, *Arch. Otolaryng.* **29**: 709-712 (April) 1939. (d) Mangabeira-Albernaz<sup>2c</sup>.

7 (a) Moure, E. J. *Rev. de laryng.*, Paris **15**: 1121-1127, 1895. (b) Arslan, Y. *Arch. ital. d. otol.* **14**: 466-470, 1902-1903. (c) Beck, J. C. *Illinois M. J.* **9**: 137-140, 1906. (d) Urbantschitsch, I. E. *Arch. f. Ohrenh.* **80**: 145, 1909. (e) von Hammerschlug, cited by Urbantschitsch<sup>7d</sup>. (f) Brady, A. J. *Ann. Otol., Rhin. & Laryng.* **21**: 787-789, 1912. (g) Fraser<sup>6a</sup>. (h) Junca, E. *J. de med. de Bordeaux*, **43**: 595, 1913. (i) Calabresi<sup>4</sup>. (j) Bronzini<sup>3</sup>. (k) Specht and Volker<sup>6b</sup>. (l) Jones, J. A. *J. Laryng. & Otol.* **45**: 265-266, 1930. (m) Svartman, J. *Angiome de l'oreille moyenne*, Thesis, Paris, Jouve & Cie, 1932. (n) Goekoop,

middle ear One<sup>8</sup> named the middle ear and external canal, one,<sup>9</sup> the middle ear and the petrosa, and another,<sup>10</sup> the middle ear or the petrosa Two authors,<sup>11</sup> after discussing the rarity of true tumors of the tympanic membrane, each reported a proved case, two<sup>12</sup> reported the drum membrane as the probable site of origin, three others<sup>13</sup> reported the site as the drum membrane, but information I gathered did not prove or disprove the contention, another<sup>14</sup> named the "middle ear, probably the posterior surface of the drum", one gave the location as the "inner ear or roof of the middle ear", two<sup>15</sup> reported the petrosa, and one<sup>6c</sup> gave the origin as "the temporal bone" In the last case the skull showed extensive involvement, and it was thought that the dura and the brain were involved, in spite of all this evidence, only the seventh nerve was affected Only one author<sup>7z</sup> mentioned the external auditory canal as the site of origin Buck<sup>2b</sup> reported a case of cavernous hemangioma arising from the malleus

Carrea and Insausti<sup>7x</sup> stated that vascular tumors are the rarest of the uncommon tumors arising in the middle ear, they divided the clinical picture into four stages (a) in the first stage the tumor remains in the tympanic cavity, (b) in the second stage it invades the surrounding areas of diminished resistance, usually appearing first in the external auditory canal, (c) in the third stage the tumor destroys the petrosa and invades the base of the skull, and (d) in the fourth stage the growth of the mass is sufficient to produce intracranial pressure

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C Acta oto-laryng **18** 153-162, 1932, Nederl tijdschr v geneesk **76** 2679-2681, 1932 (o) Busacca, G Arch ital di otol **40** 353-369, 1929 (p) Bergara, R, and Bergara, C Rev Asoc med argent **47** 150-156, 1933 (q) Causse, R Ann d'oto-laryng, 1933, pp 222-224 (r) Sullivan<sup>5</sup> (s) Seiffert, A Ztschr f Hals-, Nasen- u Ohrenh **35** 348-351, 1934 (t) Barola, A Boll d mal d orrechio, d gola, d naso **53** 185-197, 1935 (u) McKenzie, W J Laryng & Otol **54** 487-492, 1939 (v) Mangabeira-Albernaz<sup>2c</sup> (w) Weaver, D F Ann Otol, Rhin & Laryng **52** 507-515, 1943 (x) Carrea, R M E, and Insausti, T Rev Asoc med argent **57** 281-286, 1943 (y) Capps, F C W J Laryng & Otol **59** 342-346, 1944 (z) Dixon, O J Ann Otol, Rhin & Laryng **54** 415-420, 1945

8 Piazza, A Ann d mal de l'oreille, du larynx **42** 178-180, 1923

9 Haake, H Ztschr f Laryng, Rhin **21** 208-213, 1931

10 Somogyi, I Deutsche Ztschr f Nervenl **134** 211-216, 1934

11 (a) Fischer, J Ztschr f Hals-, Nasen- u Ohrenh **5** 22-32, 1923 (b) Kepes, P Monatschr f Ohrenh **72** 798-808, 1938

12 (a) Jeschek, J Monatschr f Ohrenh **70** 1297-1302, 1936 (b) Scott, S J Laryng & Otol **54** 601-605, 1939

13 (a) Arslan<sup>7b</sup> (b) Laya, J Semana med **29** 894-897, 1922 (c) Richman, F Laryngoscope **38** 94-97, 1928

14 Falk, G Acta oto-laryng **31** 436-443, 1943

15 (a) Politzer<sup>2a</sup> (b) Jack, F L Tr Am Otol Soc **12** 539-544, 1912

*Presenting Signs*—The first signs are variable. A pulsating tinnitus synchronous with the pulse was reported in 5 cases<sup>16</sup>. Tinnitus without description of the type was reported as characteristic in 10 other cases<sup>17</sup>.

In 8 cases the first sign was a red drum membrane<sup>18</sup>. In 1 of these, Jescheck<sup>12a</sup> noted that the redness increased each month with the menstrual period—the condition in this case, incidentally, was first diagnosed as “grip otitis”. One writer<sup>7s</sup> reported “proliferations behind the drum membrane”. A number of these red drums were incised, some of them repeatedly, the operation being followed by severe hemorrhage which required packing to control.

Loss of hearing alone was the first sign in 3 cases<sup>19</sup>, loss of hearing with tinnitus, in 6 cases<sup>20</sup>, loss of hearing with pain, in 2 cases<sup>21</sup> and with pain and tinnitus in 1 case,<sup>7p</sup> and loss of hearing with a mass in the external canal or middle ear, in 5 cases<sup>22</sup>, in the one last referred to<sup>17h</sup> tinnitus was also present. In others deafness developed later through the enlargement of the tumor. As might be expected, the original loss of hearing is of the conductive type, but in 15 of the 55 cases covered by this paper involvement of the eighth cranial nerve developed during the course of growth of the tumor<sup>23</sup>.

A polypoid mass was found as an early sign in many of the cases and was often treated as a simple polyp until such treatment produced severe hemorrhages and further studies were made. In a number of cases the mass showed a definite pulsation. This pulsation could occur in a simple aural polyp, developing in the presence of a chronic infection with necrosis of the tegmen tympani, so that dural pulsation would be transmitted to the mass. If pulsation is found, the case requires study before any further treatment is started. One can readily demonstrate the pulsation by placing a cotton-tipped applicator under the mass and allowing the distal end to hang free. Pulsation, if present, will cause

16 Beck<sup>7c</sup> Svartman<sup>7m</sup> Bergara and Bergara<sup>7p</sup> Carrea and Insausti<sup>7x</sup>

17 (a) Urbantschitsch<sup>7d</sup> (b) Fraser<sup>6a</sup> (c) Layera<sup>13b</sup> (d) Goekoop<sup>7n</sup> (e) Busacca<sup>7o</sup> (f) Barola<sup>7t</sup> (g) Scott<sup>12b</sup> (h) Hampton, A. O., and Sampson, D. A. *Am J Roentgenol* **41** 25-31, 1939 (i) Carrea and Insausti<sup>7x</sup> (j) Falk<sup>14</sup>

18 Svartman<sup>7m</sup> Goekoop<sup>7n</sup> Jescheck<sup>12a</sup> Scott<sup>12d</sup> McKenzie<sup>7u</sup> Capps<sup>7v</sup> Falk<sup>14</sup>

19 (a) Fowler, E. P. *Laryngoscope* **41** 474-478, 1930 (b) Haiké<sup>9</sup> (c) Capps<sup>7v</sup>

20 Beck<sup>7c</sup> Layera<sup>13b</sup> Busacca<sup>7o</sup> Scott<sup>12b</sup> Carrea and Insausti<sup>7x</sup>

21 Jack<sup>15b</sup> Capps<sup>7v</sup>

22 Arslan<sup>7b</sup> Piazza<sup>8</sup> Bronzini<sup>3</sup> Irgens<sup>6c</sup> Hampton and Sampson<sup>17h</sup>

23 von Hammerschlug<sup>7o</sup> Fraser<sup>6a</sup> Specht and Volker<sup>6b</sup> Fowler<sup>19a</sup> Goekoop<sup>7n</sup> Busacca<sup>7o</sup> Causse<sup>7a</sup> Sullivan<sup>5</sup> Somogyi<sup>10</sup> Sciffert<sup>7s</sup> Irgens<sup>6c</sup> Mangabeira Albermarz<sup>2c</sup>

an up and down excursion of the free end This fact was beautifully demonstrated in my case reported here

Bleeding from the ear is a prominent symptom in many cases It may occur spontaneously or after trauma to the external canal It is frequently the symptom which forces the patient to the otologist

Pain may be an early or a late symptom Of the series under consideration, it was reported to be present in 14 cases pain in the

*Involvement of Cranial Nerves in Cases of Hemangioma of the Ear and Mastoid Process\**

Author Reporting Case	Nerves Involved											Cervical Sympathetic Nerves
	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
Beck <sup>7c</sup>					+							
Politzer <sup>2a</sup>					+							
von Hammerschlug <sup>7e</sup>					+						+	
von Hammerschlug <sup>7e</sup>					+	+					+	
Fraser <sup>6a</sup>			+		+	+	+	+	+	+	+	+
Calabresi <sup>4</sup>					+							
Piazza <sup>8</sup>					+							
Specht and Volker <sup>6b</sup>					+	+		+				
Fowler <sup>19a</sup>						+		+	+	+	+	+
Goekoop <sup>7n</sup>			+		+	+	+	+				
Goekoop <sup>7n</sup>			+		+	+	+				+	
Goekoop <sup>7n</sup>			+	+	+	+					+	
Busacca <sup>7o</sup>				+	+	+	+	+	+	+	+	+
Zander <sup>26i</sup>					+	+	+	+	+	+	+	+
Bergara and Bergara <sup>7p</sup>					+	+						
Halke <sup>9</sup>			+		+		+				+	
Causse <sup>7q</sup>					+	+						
Sullivan <sup>5</sup>					+	Cochlear only						
Somogyi <sup>10</sup>	+		+	+		+	+	+	+	+	+	
Seiffert <sup>7s</sup>					Right			Left	+	+		
Barola <sup>7t</sup>			+		+							
Irgens <sup>6c</sup>					+							
Hampton and Sampson <sup>17h</sup>			+		+	+		+		+		
Hampton and Sampson <sup>17h</sup>			+	+	+	+					+	
Mangabeira Albernaz <sup>2c</sup>	+	+		+			+	+	+	+	+	
Monteiro <sup>30s</sup>					+							
Carrea and Insausti <sup>7x</sup>			+		+	+	+	+	+	+	+	
Dixon <sup>7z</sup>					Irritated							

\* Involvement is indicated by +

ear in 7 cases,<sup>24</sup> pain in the ear radiating to the shoulder in 1 case,<sup>19a</sup> pain in the ear radiating to the occiput in 1 case,<sup>17h</sup> pain in the mastoid area in 2 cases,<sup>25</sup> pain in the shoulder and neck in 2 cases <sup>7n</sup> and pain in the ear and the entire side of the head in 1 case <sup>11b</sup>

24 Beck <sup>7c</sup> Jack <sup>15b</sup> Fraser <sup>6a</sup> Bergara and Bergara <sup>7p</sup> Sullivan <sup>5</sup> Weaver <sup>7w</sup> Capps <sup>7y</sup>

25 Calabresi <sup>4</sup> Specht and Volker <sup>6b</sup>

Otorrhea was present in 19 cases<sup>26</sup> In some of these cases the discharge had been present for a long time prior to the clinical development of the tumor, and then the area had been dry for years, in other cases the discharge had appeared a comparatively short while before the tumor, and in still others the discharge had appeared after and apparently as the result of the tumor It is possible that the congestion incident to the infection in those cases in which the infection appeared before the clinical development of the tumor played an active part in the further development of a congenitally present nucleus of a hemangioma

In the 28 reports of cases in the literature in which involvement of cranial nerves was recorded, the first and second nerves were the only ones not mentioned In 2 cases<sup>27</sup> the third-nerve was paralyzed, as was shown by the loss of function of the superior and inferior rectus muscles, in 1 of these<sup>2c</sup> there was also involvement of the fourth nerve, with weakness of the superior oblique muscle The last-mentioned case was the only one in which that nerve was reported to be involved, and the involvement may have been due to pressure of collections of blood and serum found within the cranial cavity at autopsy In this case there was a pronounced increase in intracranial tension, with choked disks

The fifth nerve was involved in 10 cases,<sup>28</sup> as was shown by diminished corneal and conjunctival sensitivity,<sup>7n</sup> pain in the face,<sup>6b</sup> hypoguesia of the anterior two thirds of the tongue<sup>2c</sup> and inability to close the eye<sup>7t</sup> In the other cases in which this nerve was involved the symptoms were not stated, but just the fact of the involvement was noted

Involvement of the sixth nerve was present in 5 cases<sup>29</sup> and was demonstrated by paralysis of the external rectus, with convergent strabismus and diplopia

The seventh nerve, being in the most exposed position, was affected in 25 of the 28 cases with involvement of cranial nerves, paralysis

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26 (a) Moure<sup>7a</sup> (b) Arslan<sup>7b</sup> (c) Buck<sup>2b</sup> (d) Politzer<sup>2a</sup> (e) Jack<sup>15b</sup> (f) Junca<sup>7h</sup> (g) Richman<sup>13c</sup> (h) Specht and Volker<sup>6b</sup> (i) Jones<sup>71</sup> (j) Svartman<sup>7m</sup> (k) Goekoop<sup>7n</sup> (l) Zander Internat Zentralbl f Ohrenh 35 182-183, 1932 (m) Barola<sup>7t</sup> (n) Jeschek<sup>12a</sup> (o) Irgens<sup>6c</sup> (p) Hampton and Sampson<sup>17h</sup> (q) Mangabeira-Albernaz<sup>2c</sup> (r) Carrea and Insausti<sup>7x</sup> (s) Dixon<sup>7z</sup>

27 Somogyi<sup>10</sup> Mangabeira-Albernaz<sup>2c</sup>

28 Fraser<sup>6a</sup> Goekoop<sup>7n</sup> Haik<sup>9</sup> Somogyi<sup>10</sup> Barola<sup>7t</sup> Hampton and Sampson<sup>17h</sup> Carrea and Insausti<sup>7x</sup>

29 Goekoop<sup>7n</sup> Busacca<sup>7o</sup> Somogyi<sup>10</sup> Hampton and Sampson<sup>17h</sup> Mangabeira-Albernaz<sup>2c</sup>

being present in all but 1 case,<sup>7z</sup> in which the nerve was reported as "irritated" <sup>30</sup>

The eighth nerve was involved in 15 cases<sup>31</sup> In 1 of these<sup>5</sup> the cochlear portion alone was affected, in all the others the entire nerve apparently was involved

The ninth nerve appeared affected in 8 cases,<sup>32</sup> as was shown by difficulty in swallowing and loss of taste in the posterior third of the tongue

The tenth nerve was involved in 10 cases<sup>33</sup> Hoarseness was present in 5 of these cases,<sup>34</sup> and paralysis of the soft palate in 4 cases<sup>35</sup> Reports of the others simply mentioned the involvement of the nerve

The eleventh nerve was involved in 7 cases,<sup>36</sup> as was shown by the paralysis or weakness of the sternocleidomastoid and trapezius muscles

The twelfth nerve was involved in 12 cases,<sup>37</sup> as was shown by paralysis of one side of the tongue and difficulty with speech In 4 cases there was hemiatrophy of the tongue<sup>38</sup> The twelfth nerve could become involved only if the process had eroded to the petrous tip, with extension of the pressure to the bulbar area or down into the neck

The cervical sympathetic nerves were reported involved in 3 cases<sup>39</sup>

In spite of the fact that in 7 of these cases there was involvement of the last four cranial nerves,<sup>40</sup> in only 3 of them<sup>41</sup> could a diagnosis

30 (a) Beck <sup>7c</sup> (b) Politzer <sup>2a</sup> (c) von Hammerschlug <sup>7e</sup> (d) Fraser <sup>6a</sup> (e) Junca <sup>7h</sup> (f) Piazza <sup>8</sup> (g) Specht and Volker <sup>6b</sup> (h) Goekoop <sup>7n</sup> (i) Busacca <sup>7o</sup> (j) Zander <sup>26l</sup> (k) Bergara and Bergara <sup>7p</sup> (l) Haike <sup>9</sup> (m) Causse <sup>7q</sup> (n) Sullivan <sup>5</sup> (o) Seiffert <sup>7s</sup> (p) Barola <sup>7t</sup> (q) Irgens <sup>6c</sup> (r) Hampton and Sampson <sup>17h</sup> (s) Monteiro, A Hospital, Rio de Janeiro **23** 271-275, 1943 (t) Carrea and Insausti <sup>7x</sup> (u) Dixon <sup>7z</sup>

31 von Hammerschlug <sup>7e</sup> Fraser <sup>6a</sup> Specht and Volker <sup>6b</sup> Fowler <sup>19a</sup> Goekoop <sup>7n</sup> Busacca <sup>7o</sup> Bergara and Bergara <sup>7p</sup> Causse <sup>7q</sup> Sullivan <sup>5</sup> Somogyi <sup>10</sup> Hampton and Sampson <sup>17h</sup> Carrea and Insausti <sup>7x</sup>

32 Fraser <sup>6a</sup> Goekoop <sup>7n</sup> Busacca <sup>7o</sup> Haike <sup>9</sup> Somogyi <sup>10</sup> Mangabeira-Albernaz <sup>2c</sup> Carrea and Insausti <sup>7x</sup>

33 Frazer <sup>6a</sup> Specht and Volker <sup>6b</sup> Fowler <sup>19a</sup> Goekoop <sup>7n</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup> Seiffert <sup>7s</sup> Hampton and Sampson <sup>17h</sup> Mangabeira-Albernaz <sup>2c</sup> Carrea and Insausti <sup>7x</sup>

34 Specht and Volker <sup>6b</sup> Fowler <sup>19a</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup> Hampton and Sampson <sup>17h</sup>

35 Fowler <sup>19a</sup> Goekoop <sup>7n</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup>

36 Fraser <sup>6a</sup> Fowler <sup>19a</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup> Seiffert <sup>7s</sup> Mangabeira-Albernaz <sup>2c</sup> Carrea and Insausti <sup>7x</sup>

37 von Hammerschlug <sup>7e</sup> Fraser <sup>6a</sup> Fowler <sup>19a</sup> Goekoop <sup>7n</sup> Busacca <sup>7o</sup> Haike <sup>9</sup> Somogyi <sup>10</sup> Seiffert <sup>7s</sup> Hampton and Sampson <sup>17h</sup> Mangabeira-Albernaz <sup>2c</sup> Carrea and Insausti <sup>7x</sup>

38 von Hammerschlug <sup>7e</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup>

39 Fraser <sup>6a</sup> Fowler <sup>19a</sup> Busacca <sup>7o</sup>

40 Fraser <sup>6a</sup> Fowler <sup>19a</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup> Seiffert <sup>7s</sup> Mangabeira-Albernaz <sup>2c</sup> Carrea and Insausti <sup>7x</sup>

41 Fowler <sup>19a</sup> Busacca <sup>7o</sup> Somogyi <sup>10</sup>

of a jugular foramen syndrome be made from the symptoms reported. The patient in 1 other case showed a beginning jugular foramen syndrome,<sup>78</sup> with weakness of the tongue, vocal cords and sternocleidomastoid and trapezius muscles. This patient died before the disease progressed further, and autopsy showed that the tumor had invaded the lateral sinus and the jugular vein.

*Treatment*—There was considerable diversity in the matter of treatment. In 27 cases a radical mastoidectomy was apparently performed, and in 1 case the operation could not be completed because of hemorrhage. The internal and external carotid arteries were ligated in this case. In another the internal carotid artery was ligated because of the bleeding. In 5 cases roentgen radiation was used with radical mastoidectomy, and in 1 case radium radiation was given in addition. In 1 case radium therapy was used after the mastoidectomy. In 2 cases electrocoagulation was done with the mastoidectomy. In 6 cases roentgen radiation alone, and in 3 radium radiation alone, was given. In 2 electrocoagulation and roentgen radiation were used. In 4 cases electrocautery was employed. In only 1 case was the use of a sclerosing fluid reported, but the material used was not stated. One author reported "surgery and the injection of alcohol and fresh lemon juice." In the other reports of cases in the literature either the description of the treatment was vague or the information was not available in the material supplied.

Of the 53 cases from the literature, the result of treatment was available in only 32. In 8 the patients were reported as having recovered, in 6, they were improved, in 2 the hemangioma recurred, in 1 it "recurred and progressed", in 3 the growth "progressed" and the patient presumably died (these were cases with extensive involvement before the patients were seen by the otologist, and no surgical operation was attempted), 8 patients died because of the condition (2 of these were the 3 year old and 5 year old children reported earlier in this paper, and the others were persons who delayed for years before consulting an otologist), 1 patient died of meningitis, 1 died eight years after operation, of pneumonia, 1 died after an operation for the repair of hernia, and 1 was simply reported as showing "no improvement."

With the patient under proper care, instituted early enough, the prognosis appears to be relatively good except in the cases of tumor developing in early childhood or up to about puberty. Radical mastoidectomy followed by roentgen irradiation I believe offers the best result. I believe in another case I should also give some roentgen treatment prior to operation in an effort to sclerose the mass, at least partially, and to lessen to some extent the troublesome bleeding encountered in operating.



The following cases are presented as additions to the list already reported. Both occurred in the service of Dr. George M. Coates at the Graduate Hospital of the University of Pennsylvania. The first patient was one whom I first saw in the outpatient department and operated on in December 1937, and the other was a private patient of Dr. Coates whom he operated on in March 1945 and whose case he suggested I report with mine.

#### REPORT OF CASES

CASE 1—B. M., a 36 year old Negro woman, was admitted to the Graduate Hospital on Nov. 30, 1937. She had had measles as a child but no other childhood diseases. There was no history of tonsillitis or of any aural disorders until February 1936. She said she did not smoke, drink or work. The first trouble with the ear had started in February 1936 with an earache followed by a discharge, on the left side. The patient had been treated in the outpatient department, and when seen in June 1936 she seemed entirely recovered except for some loss of hearing demonstrated by the audiometer but which she could not notice. There was no tinnitus. Apparently there were no other symptoms related to the ear until Nov. 30, 1937, at 2 a. m., when there was spontaneous bleeding from it. The patient ran to the receiving ward, where her ear was packed with cotton and she was referred to the outpatient department. Her blood pressure at that time was 140 systolic and 100 diastolic. She said that there had been no alteration in her hearing, no discharge from the ear, no pain and no tinnitus prior to the onset of the bleeding. When she was seen in the outpatient department, hospitalization was advised, and she was admitted.

On admission her blood pressure was 145 systolic and 90 diastolic. There was no localized tenderness. The right ear showed no abnormality. The left external auditory canal was filled with a large mass, which extended to the external opening of the canal. There was some purulent discharge from about it. The mass pulsed, and an applicator inserted under it moved up and down with each pulse beat. The mass bled readily. There was no tenderness of the mastoid area. The nose and sinuses appeared entirely normal. The tongue was not coated and projected in the midline. Oral hygiene was poor, but the teeth were in fair condition. The tonsils were not large, nor did they appear to be infected. There was no inflammation in the nasopharynx. There was no cervical adenopathy, no abnormal pulsation and no enlargement of the thyroid gland. The rest of the physical examination revealed nothing of significance. Reactions to the Wassermann test and the Kahn test were negative, as was that to the Eagle test. The concentration of hemoglobin was 69 per cent, the white blood cell count, 9,200, with neutrophils 83 per cent (7,636), lymphocytes 16 per cent (1,472) and mononuclear cells 1 per cent (92). The blood was Landsteiner group A. A roentgenologic examination showed no change from the one which had been taken May 13, 1936, which had shown large mastoid processes on both sides, there was a moderate degree of pneumatization on both sides, the sigmoid sinus was not seen distinctly on either side. There was evidence of an old inflammatory process bilaterally. The right mastoid bone was normal at this time. The left mastoid bone showed considerable increased density with appreciable obscuration of cellular detail. There was no definite evidence of destruction of bone, but this possibility was not excluded. The report was by Dr. Karl Kornblum.

With the patient under nitrous oxide-ether anesthesia, I performed an operation on December 3. The operation started at 3 12 p m and was not finished until 5 15 p m because of the difficulties encountered from the bleeding. A postauricular incision was made, the cortex exposed and the mastoid cells opened. There were considerable necrosis of bone and some pus, the latter particularly in the cells of the tip. There was pronounced softening of the posterior wall of the canal, which had apparently begun to sequestrate, as a piece of it lifted off, exposing the facial nerve for 2 mm or more. Excessive bleeding was encountered from the mass exposed in the external canal and attached apparently to the inner wall of the middle ear. The area had to be packed off while the removal of bone was extended upward and forward, exposing the middle fossa. The tegmen was eroded. Exposure through the middle fossa was increased so that access to the mass could be gained more readily. The pack over the bleeding mass was removed, and after some difficulty a ligature was thrown around the tumor, which was removed. No ossicles were seen. Once the ligature was about the mass the bleeding was well controlled, but up to that point it was exceedingly troublesome and distinctly slowed the operation. All necrotic bone was removed and the attachment of the tumor well cleaned up, again with troublesome bleeding until the end. The cavity was carefully packed, with due attention to the exposed facial nerve, and when the patient left the table there was definitely no facial weakness. Dr Case reported the mass as a hemangioendothelioma, and the culture from the mastoid cells showed *Corynebacterium diphtheriae*.

During the next three days there was a gradual onset of facial paralysis, until by the third day it was complete on the left side in spite of the fact that the packing in the nerve area had been loosened the first day after operation. There was no abnormal bleeding at any of the dressings and, except for involvement of the facial nerve, convalescence was uneventful. The patient was discharged December 18, fourteen days after operation, and told to report to the outpatient department for follow-up observation. She did so for some time, and the ear cleared up. My colleagues and I lost track of her, until about one year later she returned to the outpatient department with a recurrence of the mass and some bleeding. The facial condition was somewhat better.

She was watched carefully, and it was observed that the slightest trauma caused bleeding. The mass was pulsating as before. Surgical intervention was talked of, but we decided to try other measures first. Electrocoagulation was attempted several times, but always with troublesome bleeding and much discomfort to the patient. Use of sclerosing fluids was considered, but I was afraid to try that method, and roentgen irradiation was decided on. The patient had several courses of treatment, the last about one year ago, and she has had no bleeding for almost two years. When she was seen on Oct 21, 1947, the mass was small and fibrotic. Some pulsation was still noted when an applicator was inserted under it, but there was no bleeding, and the patient said she had had none for about two years. The facial paralysis was considerably less, and she could close her eye and draw the corner of her mouth back, not normally but very well.

CASE 2—J L B, a married white woman aged 61, on March 2, 1938, complained of pain in the right ear of twenty-four hours' duration. The attending otologist stated that the drum membrane was pink around the margin, without bulging. Chronic otorrhea was present at the time. Soon afterward a small red swelling, resembling granulation tissue, appeared at the bottom of the canal adjacent to the drum and coalescent with it. The patient had complained of impaired hearing and tinnitus for ten days previously.

She was first seen by Dr Coates on July 21. An audiogram taken that day showed a hearing loss for the lower frequencies to far below the useful level on the right side. The right drum membrane was red and slightly bulging in the posterior half, there was some bulging in the external auditory canal. The patient complained of loss of hearing, tinnitus and occasional throbbing pain, with occasional attacks of vertigo. A roentgenogram made the next day showed a sclerotic mastoid bone with no evidence of cavitation. No treatment was administered. When next seen on July 20, 1939 the patient reported that for six months she had had difficulty with articulation. The right tympanic membrane was red and somewhat pushed out. The eustachian tube was patulous. There was no pain, but there was some tenderness about the right ear. A roentgenogram of the larynx and chest revealed a normal condition. On April 5, 1940, the patient's speech had become much worse, asthenic, jerky and spasmodic. At that time the growth had changed little in appearance, but when seen one year later, on April 23, 1941, it had nearly filled the external auditory canal, without causing any further symptoms. The larynx was normal, but the patient was seen at various times by Dr Gabriel Tucker and Dr James Sonnett Greene for her speech defect. On July 17 the growth had a slight cystic feel. The patient was seen again on April 24, 1942, and June 23, 1944, when there was little change in her condition.

On Feb 26, 1945, she was again seen by Dr Coates and reported that, seven days before, she had had a hemorrhage from the ear at night, and again after manipulation by the attending otologist in Harrisburg. The bleeding had lasted two hours and had been followed by slight oozing for several days. Partial paralysis of the facial nerve was noted for the first time. A roentgenogram taken on March 14 showed nothing new, except a small erosion cavity of the posterior bony wall of the canal. The patient was admitted to the Graduate Hospital on March 19, and a specimen for biopsy was taken with a high frequency cutting loop. The pathologic report was "benign polyp." On March 24 a radical mastoidectomy was done by Dr Coates. The mastoid cells were observed to be denuded of mucous membrane, and there was some necrosis of bone. The facial nerve was found pathologically exposed. A large mass of friable, bleeding tissue filled the middle ear, with erosion of the posterior wall of the canal. The bleeding made completion of the operation difficult. The facial paralysis was severer after the operation, probably because of pressure from the packing, which was removed the fourth day. The mastoid wound healed nicely, with early epidermatization. The pathologist (Dr Eugene Case) reported hemangioendothelioma. There was a small recurrence of the growth later, but a recent examination showed that it had remained stationary. Her facial paralysis and voice defect remained unchanged. Dr Tucker said that he considered the voice defect a functional condition. Though at one time the patient had had leukoplakia of the right cord, this had cleared up entirely, without benefit to the speech.

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# CLINICAL AND PATHOLOGIC AURAL FINDINGS IN A CASE OF CARCINOMATOSIS OF THE MENINGES

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REPORTS of carcinomatosis of the meninges since Saenger's<sup>1</sup> first publication in 1900 have been few. Although the condition occurs more frequently than the few reports would indicate, the number of reports including the pathologic changes occurring in the ear in this disease have been fewer (Schlittler,<sup>2</sup> Wagener,<sup>3</sup> Mayer,<sup>4</sup> Hellmann,<sup>5</sup> Brunner,<sup>6</sup> Barth,<sup>7</sup> Meller<sup>8</sup>). In the case which is described later the ears revealed many clinical and pathologic changes.

Carcinomatosis of the meninges is characterized clinically by symptoms of meningeal irritation and eventually by increase of intracranial pressure, followed by simultaneous appearance of symptoms of involvement of the cranial nerves and the spinal cord.

There is a dense accumulation of tumor cells in the subarachnoid space. The cells follow the flow of the cerebral spinal fluid and reach the subarachnoid sheaths of the cranial and spinal nerves. At the points where the nerves penetrate the dura there is a narrowing of the sheaths causing the cancerous cells to congregate, probably owing to the stag-

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From the former Ear, Nose and Throat Department of Docent H. Brunner at the Allgemeine Polyclinic of Vienna.

1 Saenger, A. Ueber Hirnsymptome bei Carcinomatose, *Neurol. Zentralbl.*, 1901, p. 1086.

2 Schlittler, E. Ueber das metastatische Karzinom des Gehörorgans und über dessen Beziehungen zur Meningitis carcinomatosa, *Arch. f. Ohren-, Nasen- u. Kehlkopfh.* **103** 121, 1919, Ueber Meningitis carcinomatosa, *Schweiz. med. Wchnschr.* **56** 763, 1926.

3 Wagener, O. Zur Pathologie des Ohres bei Meningitis carcinomatosa, *Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres* **14** 83, 1920.

4 Mayer, O. Metastatisches Karzinom des Gehörorgans, *Monatsschr. f. Ohrenh.* **56** 541, 1922.

5 Hellmann, K. Zur Lehre vom metastatischen Carcinom des Hörnerven, *Ztschr. f. Hals-, Nasen- u. Ohrenh.* **4** 157, 1922-1923.

6 Brunner, H. Beiträge zur otologischen Diagnostik der Hirntumoren. Das Verhalten des Schläfenbeines bei Hirncysticercose und bei Meningitis carcinomatosa, *Monatsschr. f. Ohrenh.* **68** 257, 1934, Case of Carcinomatosis of the Meninges, *Ann. Otol., Rhin. & Laryng.* **50** 910, 1941.

7 Barth, H. Ueber Carcinommetastasen im Felsenbein, *Ztschr. f. Hals-, Nasen- u. Ohrenh.* **37** 181, 1935.

8 Meller, H. Zur Frage der Meningitis carcinomatosa des Schläfenbeines, *Wien. klin. Wchnschr.* **52** 114, 1939.

nation of the cerebral spinal fluid at these points. The accumulated cells cause a bulging of the nerve sheaths above these points.

#### REPORT OF CASE

C. F., aged 52, white, a housewife, stated that she had always been healthy. In the beginning of October 1937 she fell backward from a height of 4 feet (about 1 meter). She did not lose consciousness and suffered no ill effects. On October 31 she had a severe occipital headache, accompanied by emesis and vertigo, but no visual disturbances. She noticed, however, variation in her auditory acuity, at one time hearing would be acute, and at other times she was unable to hear though spoken to from a point close to her ear. These complaints continued unabated, and she was admitted to the hospital on November 16.

Her family history revealed that her mother had died of carcinoma, but she could not specify its exact nature.

*Neurologic Findings*—*Head*. There was tenderness of the occiput on palpation and distinct and diffuse pain on percussion, particularly over the left side of the occiput, which caused the patient to wince. An attempt to turn the head to the extreme left caused severe pain in her neck.

The pupils were of medium size, equal, regular, and reacted well to light and accommodation. Slight weakness of the lower part of the left side of the face was also present.

*Eyes*. There was weakness of upward and downward gaze, while on lateral gaze the eyes reached the end position but could not be held there. When looking sideward the eyes revealed a horizontal rotatory nystagmus in the end position, bilaterally, while looking upward they showed a few diagonal oscillations to the right, while looking downward they revealed rotatory nystagmus. There was skew deviation of the eyes. The visual fields showed no abnormalities.

There was a choking of the disk of 2 diopters on the right side, and the veins were enlarged on the left side. Diplopia was not evident. The right corneal reflex was slightly diminished, the left was normal.

*Ears*. The ear drums were retracted on both sides. The low intelligence of the patient did not permit accurate results to be obtained with the tuning forks. Repeated examination showed variation of the acuity of hearing. One day the patient did not hear conversational voice close to her ear, and on another day she was able to hear well from a distance of 10 feet (3 meters). The caloric test yielded normal irritability on the right side and diminished irritability on the left side.

*Upper Extremities*. There was no paresis, no atrophy, no ataxia with the finger to nose test. The deep reflexes were active and equal. No changes of sensibility were recorded. The tendency toward pronation was more pronounced in the right arm than in the left. The rebound phenomenon was present on both sides, and further examination revealed disturbed stereognosis on the right side.

*Lower Extremities*. On standing without support the patient swayed and tended to fall to the left and backward. Although reluctant to start walking, after she had overcome this reluctance her gait was clear. She walked stiffly and deviated to the left side, taking small steps and not lifting her feet from the ground. Her arms did not move but were held stiffly in adduction.

*Internal Examination*—The roentgen examination of the head, the chest and the gastrointestinal tract revealed no pathologic changes. The Wassermann

reaction of the blood was negative, and examination of the blood showed hypochromic anemia and an accelerated sedimentation rate

On November 19 a ventriculographic examination failed to reveal any abnormal condition. The cerebrospinal fluid findings were slight increase of protein, no increase of cells, no presence of epithelial cells

The clinical diagnosis of cerebral tumor was made, but as the patient showed signs of rapid weakening, an operation was not performed. The patient died on December 9

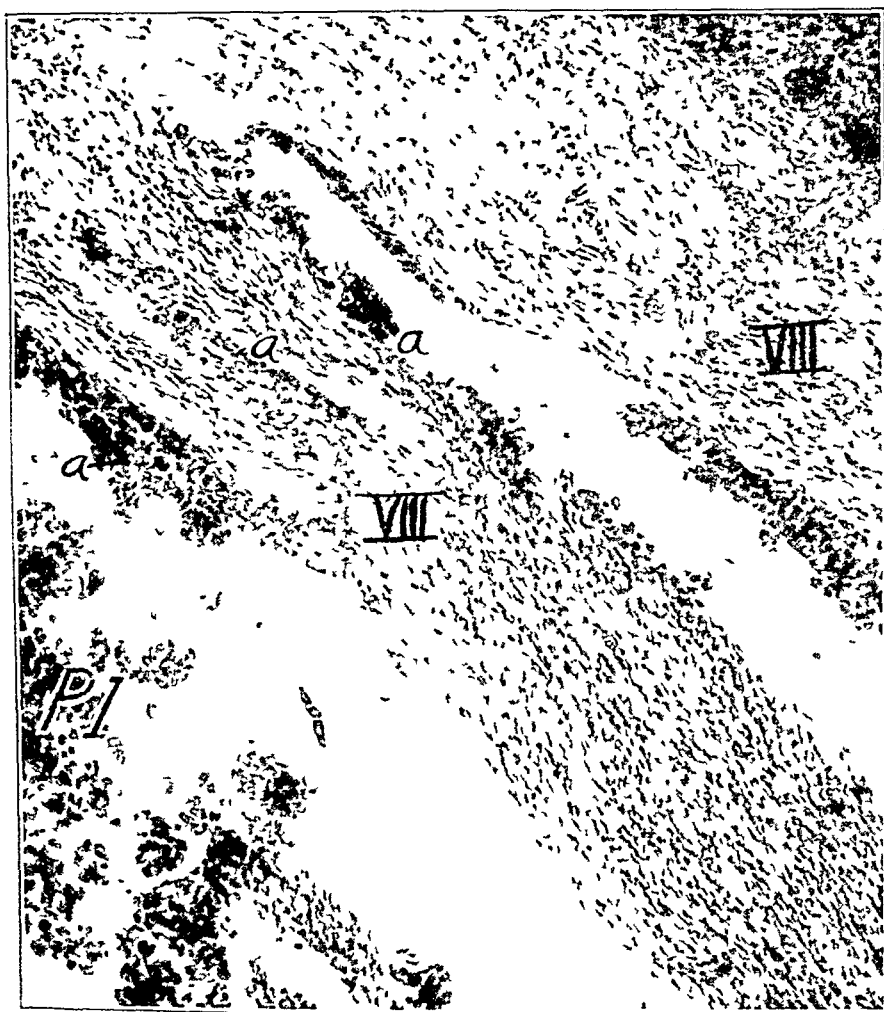


Fig 1—Cross section of the cerebellopontile angle. *PI* is the choroid plexus, *VIII*, the eighth nerve, covered and infiltrated by carcinoma cells (*a*)

In the calvaria, at autopsy, there was an opening 6 mm in diameter on each side, the dura was well stretched and the large sinuses were free. The leptomeninges of both occipital lobes were slightly infiltrated with blood, the gyri were enlarged and flattened and the sulci narrow. Above the cerebellum and toward the right the leptomeninges were completely filled with small yellow-white spots. In the right cerebellopontile angle the consistency of the brain substance was harder than that on the corresponding left side. The brain was put into 4 per cent formaldehyde solution without being sectioned. Micro-

was enlarged and the antrum was wide. A large vein originating in the jugular bulb ran through the posterior wall of the bulb and entered the dura of the posterior fossa of the brain.

The windows were normal. In the region of the tube and in the tegmen tympani there were many pacchionian granulations which contained numerous cancer cells and dug deep fossae into the bone (fig 3). The internal meatus was slightly enlarged, and its upper and posterior walls showed numerous lacunas without osteoclasts. The bone of the internal meatus was absorbed by engorged veins which paralleled the bone in long rows and absorbed the bone by means of endothelial cells.

All the nerves of the inner auditory canal were infiltrated with cancer cells (fig 4). The cancer cells invaded the connective tissue part of the nerve, distal to the Alexander-Obersteiner glia-septum, whereas the proximal part of the acoustic nerve remained unaffected. The cancer cells invaded the connective tissue of the nerve and became more and more numerous in the region of the fundus of the internal auditory canal, where they destroyed the cochlear nerve completely and invaded the modiolus along the blood vessels (fig 5). The vestibular ganglion had disappeared. The cancer cells likewise invaded the glossopharyngeal nerve and the petrosal ganglion.

The cancer consisted of large cells with well developed, eosin-staining protoplasm and vesicular, eccentrically situated nuclei. The cells were polygonal when they were in rows between the nerve fibers and round when they were free in the tissue. Often they formed glandular-like tubes without secretion. Quite often there were giant cells with two or more nuclei. Finally there were large and small foci of necrosis among the cancer cells.

In the tractus spiralis foraminosus the cancer cells could be recognized only with great difficulty, because the periosteal connective tissue was much thickened and hyalin degenerated, causing compression and degeneration of the cancer cells. Cancer cells were also found in Rosenthal's canal. Here they completely replaced the spiral ganglion, especially in the basal coil, and entered the spiral nerve, but they never appeared among the two tables of the spiral lamina (fig 6). Occasionally in the spiral ganglion of the middle and the top turn, cancer cells were found.

The cancer cells penetrated farther into all branches of the vestibular nerve. In the region of the saccular nerve they could be followed until the macula cribrosa was reached, but there were no cancer cells in the macula of the saccule. In the region of the utricle the cells did not extend to the macula cribrosa, so that of all the sensorial organs of the labyrinth, the utricle was best provided with nerves. The cancer cells invaded the foramina of the macula cribrosa of all three cristae ampullares without causing a thickening of the periosteum of these channels. Cancer cells could likewise be found in the connective tissue of all three cristae.

In all spaces of the internal ear there was a cell-free fluid which stained with eosin and must be considered as a transudate. All capillaries of the inner ear were engorged. In the macula sacculi there was a fresh hemorrhage, likewise in the vestibule and the scala tympani and in the cochlear aqueduct. In the inferior utricular recess there was an atypical epithelial spot. There were artificial changes of Corti's organ. Only the pillar cells were well preserved. The stria vascularis was normal and had here and there cells rich in protoplasm close to the capillaries. The question whether these cells were cancer cells could not be answered. Corti's membrane was adherent to Corti's organ and the latter to Reissner's membrane, so that the duct filled with serous fluid was markedly narrowed. In between the

spiral laminae there were a few degenerated nerve fibers. The pigment content of the cochlea was normal. The cochlear aqueduct was free. In the region of its cerebral opening there were several pacchionian granulations infiltrated with



Fig 4—Section through the facial nerve (*F*) and the cochlear nerve (*C*) in the internal auditory meatus (*Mai*). *a* indicates the zone of Alexander-Obersteiner. Note the infiltration of the cochlear and facial nerve with carcinoma cells.



cancer cells From the internal meatus the cancerous infiltration extended into the facial nerve and could be followed up to the geniculate ganglion In the horizontal portion of the facial nerve a remarkable reduction of the number of nerve fibers was noted, but no cancerous infiltration The chorda tympani and the tympanic (Jacobson's) nerve were normal

Right Side The tube, the antrum and the middle ear were large There was pronounced pneumatization of the tegmen and normal insertion of the slightly

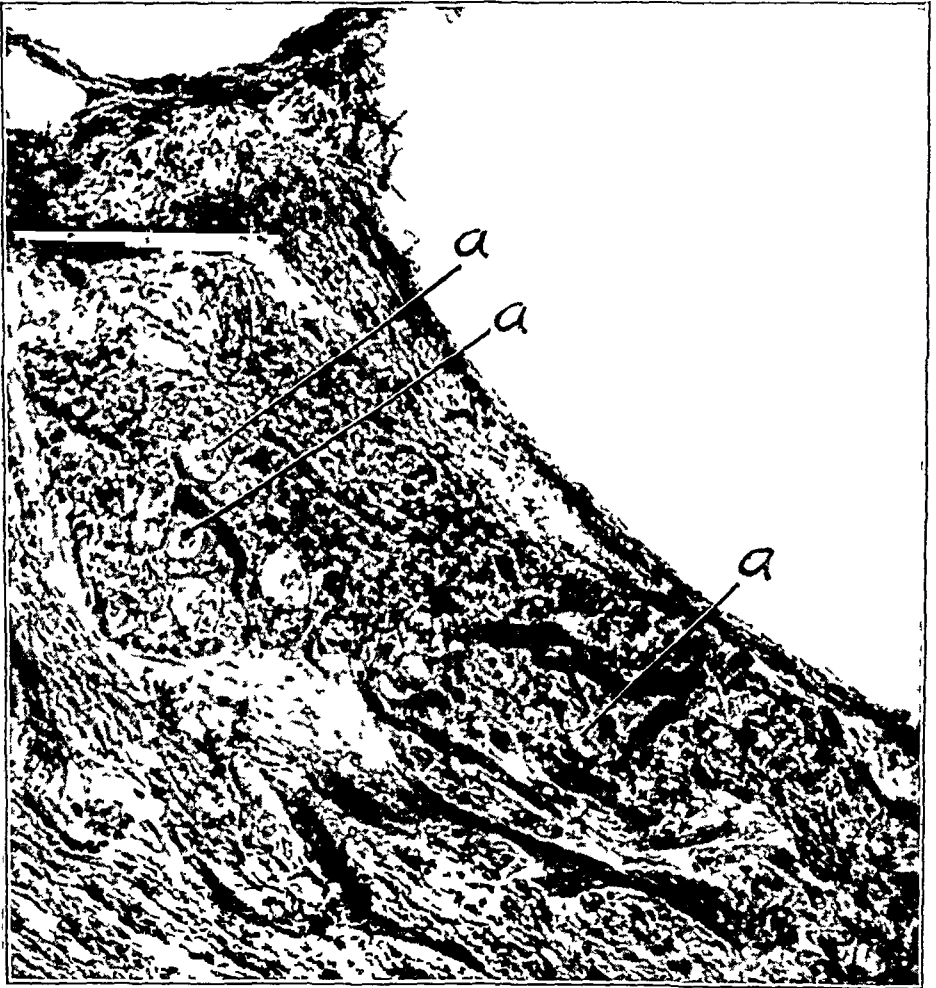


Fig 5—Section through the modiolus, *a* indicates carcinoma cell

atrophic drum membrane Malleus, incus and stapes were normal The superior petrosal sinus was thrombosed, and its walls were infiltrated with cancer cells The internal auditory canal was slightly enlarged Resorption was caused by veins but not by Pacchioni's granulations All nerves of the internal auditory meatus were infiltrated by cancer cells Carcinoma cells and corpora amylacea were found in the glial parts of the acoustic nerve The inner ear had undergone the same changes as that of the left side The modiolus showed a few more ganglion cells than that of the left The transudate was more abundant

In conclusion, the same changes took place on both sides, namely 1 The walls of the internal auditory canal had been resorbed by endothelial cells of the veins and by Pacchioni's granulations, which contained cancer cells 2 Cancerous infiltration had involved all nerves of the internal auditory meatus 3 The vestibular ganglion was missing on the left The geniculate ganglion remained free 4 The spiral ganglion in the region of the basal coil was entirely replaced by cancer cells Here and there cancer cells were also found in the spiral nerves of the basal, middle and top coils of the cochlea 5 The cancer cells extended through the holes of the macula cribrosa of all three cristae ampullares and invaded the

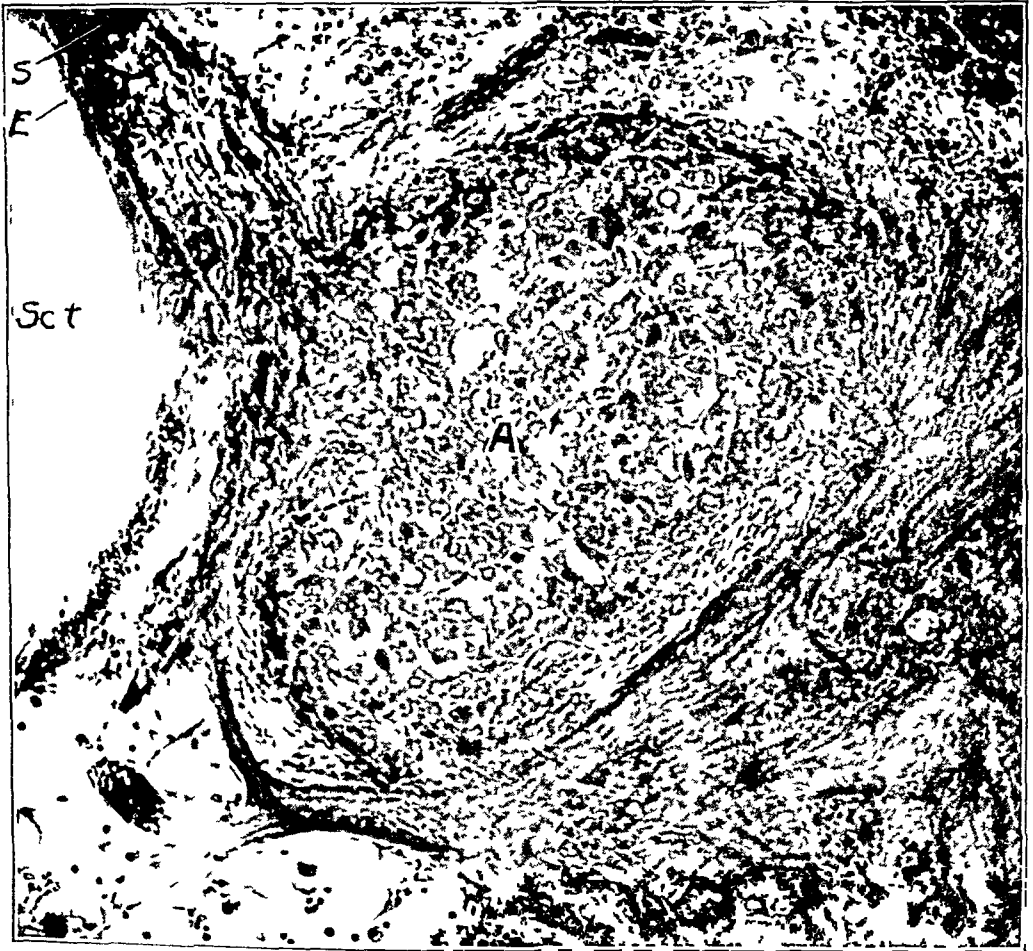


Fig 6—Cross section of the spiral ganglion of the upper portion of the basilar coil (*A*) showing carcinoma cell infiltration *Sc t* is the scala tympani, *E*, exudate, *S*, the spiral nerve

connective tissue of all three cristae 6 Fresh hemorrhages were present in the macula sacculi, the scala tympani and the aqueductus cochleae 7 There was a transudate in the cochlea, the vestibule and the labyrinth 8 The sensorial organs were not invaded

#### COMMENT

Carcinomatosis of the meninges is invariably caused by metastasis It is interesting to note that not infrequently in cases of carcinomatosis

the primary tumor cannot be discovered, not even at autopsy. This happened in the presented case, although a diligent search was made. The pathologic aspect consists of an infiltration of the meninges with carcinoma cells. The brain substance may or may not be involved. In the presented case a perivascular carcinoma cell infiltration was found in the medulla oblongata and in the cerebellum.

It was Schlittler<sup>2</sup> who in 1919 drew attention to the changes within the ear caused by carcinomatosis of the meninges. The findings consist essentially in an infiltration of the acoustic and facial nerves. The highest degree of infiltration was found in the cochlear nerve, parts of which were destroyed by the carcinoma cells. The central (glial) portion of the cochlear nerve did not contain carcinoma cells, although at its exit from the medulla oblongata the nerve was ensheathed by large masses of carcinoma cells. In contradistinction to the central portion the distal portion of the cochlear nerve contained numerous carcinoma cells, which accumulated partially in front of the tractus foraminosus. This peculiar distribution of the carcinoma cells indicates that there is no proliferation of carcinoma cells from the medulla to the fundus of the internal auditory meatus. One must assume rather that there is a transportation of carcinoma cells from the medulla oblongata to the internal meatus, the tractus foraminosus acting as a barrier which permits only a few cells to pass into the modiolus, into the spiral ganglion and eventually even into the basilar portion of the spiral nerve. It is likely that the same mechanism is acting in the distribution of carcinoma cells along the branches of the vestibular nerve, where the respective macula cribrosa acts as a barrier, and along the facial nerve, where the geniculate ganglion inhibits further progress of the carcinoma cells. In other words, there is a fluid flowing from the meningeal spaces toward the inner ear. The fluid conveys carcinoma cells and lays them down where it meets with an obstacle. From this concept one must not draw the conclusion that a centrifugal flow of this type is likewise present under physiologic conditions. This conclusion would not be correct, because carcinoma cells may be carried within lymph vessels by retrograde transportation even in the presence of valves.

The accumulated carcinoma cells exercise a destructive influence on the nerves and the ganglion cells within the internal ear and, in addition, cause passive hyperemia by compressing the veins of the internal ear. This results in destruction of great parts of the acoustic nerve of the spiral ganglion and eventually of the vestibular ganglion and in accumulation of a transudate within the inner ear. The latter finding is called "stagnation hydrops of the internal ear" (Brunner<sup>6</sup>, Fischer<sup>9</sup>).

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<sup>9</sup> Fischer, J. Changes in the Internal Ear Due to Increased Endocranial Pressure, *Arch Otolaryng* **31** 391 (March) 1940.

The pathologic observations explain to a certain extent the otologic observations, which are not uniform. Some of these patients show a slight degree, others a high degree, of deafness, some show a normal, others a subnormal or even an absence, of labyrinthine excitability. All depends on the degree of nerve destruction caused by the carcinoma cells. In the presented case the labyrinthine excitability was normal on the right side and slightly diminished on the left side. Correspondingly, the branches of the vestibular nerve showed only slight destruction. The hearing was markedly diminished, but the acuity of hearing varied. This was noticed by the patient as well as by me. It is likely that the oscillations of the acuity of hearing were caused by the stagnation hydrops of the internal ear, the degree of which is proportional to the pressure exercised by the carcinoma cells on the veins of the internal ear. Since this pressure varies according to the amount of accumulated carcinoma cells, the stagnation hydrops likewise must show fluctuation of its intensity. In fact, in some cases of carcinomatosis of the meninges no stagnation hydrops was observed, although carcinoma cells had invaded the internal meatus. It is possible that the fluctuations of the intensity of the stagnation hydrops correspond with the fluctuations of the acuity of hearing in the presented case.

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## SQUAMOSITIS, MASTOIDITIS AND SQUAMOMASTOIDITIS

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KORNER<sup>1</sup> published his report on "the septum petrosquamosum and its clinical significance" in 1927 Wolff<sup>2</sup> had previously called it the "septum mastoideum," and others,<sup>3</sup> including Korner, had described it earlier without naming it. It is now commonly called Korner's septum. Korner demonstrated the existence of two pneumatic cell systems of the mastoid process, separated by the petrosquamous septum. Their only intercommunication is via the antrum tympanicum, into which each cell system leads. The petrosquamous septum is formed in childhood by the fusion of the apposing cortical surfaces of the mastoid portions of the pars petrosa and of the pars squamosa in the formation of the mastoid process. Korner pointed out that either or both bones, with their contained independent cell systems, can be diseased in clinical mastoiditis. In the American literature the essential points made by Korner are contained in Batson's<sup>4</sup> excellent monograph on the surgical anatomy of the temporal bone.

### STATEMENT OF PURPOSE

The current nomenclature, methods of clinical and roentgenologic diagnosis and surgical treatment of mastoid disease have been little changed by Korner's observations. The clinical signs and roentgen findings depend on whether one or the other or both cell systems

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Read before the Philadelphia Laryngological Society, April 6, 1948

1 Korner, O. Die Grenzen zwischen den pneumatischen Zellensystemen des Antrum petrosum und des Antrum squamosum beim Erwachsenen, *Ztschr f Hals-, Nasen- u Ohrenh* **5** 425, 1923, Das Septum petro-squamosum (mastoideum) und seine klinische Bedeutung, *ibid* **17** 137, 1927

2 Wolff, H. I. Die klinische Bedeutung des Septum mastoideum und der durch dasselbe getrennten Cellulae squamosae und petrosae des Warzenfortsatzes, *Acta oto-laryng* **9** 254, 1926

3 Bruhl, G. Schlafenbein mit Dehiscenz des Proc mastoideus, des Sulcus sigmoideus und einem Bulbus superior, *Monatschr f Ohrenh* **46** 275, 1912. Frey, H. Ein Beitrag zur Anatomie des Schlafenbeines, *Arch f Ohrenh* **68** 44, 1906. Kirchner, W. Ueber das Vorkommen der Fissura mastoidea squamosa und deren praktische Bedeutung, *ibid* **14** 190, 187

4 Batson, O. V. Surgical Anatomy of the Temporal Bone, in Nelson's Loose-Leaf Surgery of the Ear, New York, Thos Nelson & Sons, 1947, p 127

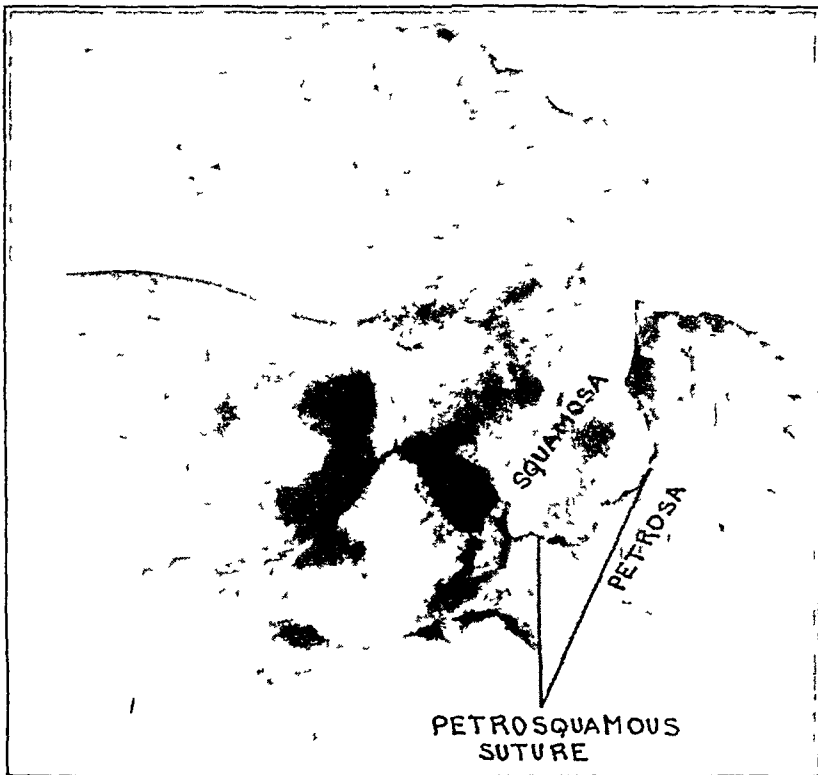


Fig 1—Left temporal bone of 12 year old boy, showing the petrosquamous suture between the pars squamosa and the pars petrosa (Specimen loaned by W F Whelan, M D, Philadelphia)

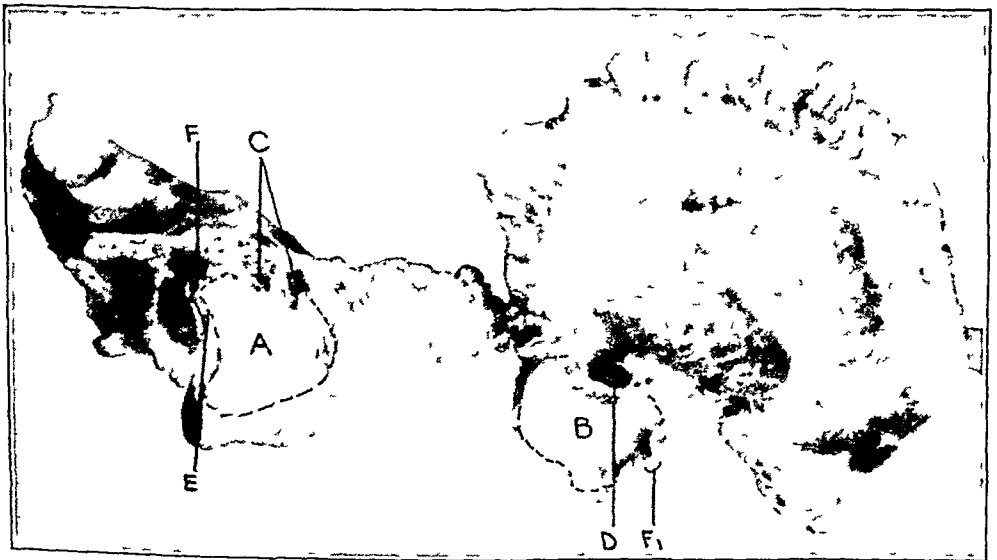


Fig 2 (same specimen as in fig 1) —The pars squamosa and the pars petrosa have been disarticulated, and the pars squamosa laid back to the right, to reveal its medial surface *A*, the petrosquamous septum, *B*, the squamosal portion of the petrosquamous septum, *C*, the petrosal antrum, *D*, the squamosal antrum, *E*, the posterior-superior border of the tympanic plate, *F* and *F*<sub>1</sub>, articulating edges of the pars petrosa and the pars squamosa within the bony external auditory meatus, which are not covered over by the tympanic plate

are diseased The purpose of this paper is to present the clinical differentiation of these three possibilities This is believed to be in order, since the existing practice of including them all under the term "mastoiditis" is paradoxical and may result in errors of diagnosis and treatment

Disease of the pars squamosa lies largely outside the mastoid process It presents a clinical picture and roentgen findings markedly different from disease of the mastoid process, and it requires special adaptations of the conventional surgical approach It is not mastoiditis



Fig 3—Right temporal bone The exenterated cellular area extends well above the linea temporalis and anterior to the external auditory meatus The superior wall of the external auditory meatus has been removed The region between the superior canal wall and the floor of the middle cranial fossa was highly pneumatic This specimen illustrates pneumatization of the pars squamosa extending beyond the confines of the mastoid process, which is limited above by the linea temporalis and anteriorly by the posterior wall of the external auditory meatus (Specimen prepared by the author)

but squamositis Disease of the pneumatic cells of the temporal bone, exclusive of the petrous pyramid, may be classified as follows (1) mastoiditis—disease of the petromastoid cell system and mastoid base of the petrous bone, (2) squamositis—disease of the squamosal cell system and squamous bone, (3) squanomastoiditis—disease of both cell systems and both bones

## CLINICAL SIGNS

In mastoiditis the cardinal points of tenderness are over the antrum tympanicum, the mastoid tip and the emissary vein. In squamositis tenderness is found in the supra-auricular region. Loss of motility of the skin due to slight edema is postauricular in mastoiditis, in squamositis it is supra-auricular or preauricular. Obliteration of creases of the skin is postauricular in mastoiditis, in squamositis it is supra-auricular. In mastoiditis displacement of the auricle is away from the head and forward, in squamositis it is away from the head and downward.

A small furuncle-like lesion with a draining apex in the posterior-superior wall of the external auditory canal, close to the drumhead, is an occasional finding in squamositis. The anatomic basis of this lesion is the subcutaneous situation at this point of the innermost portion of the petrosquamous suture. The meatal part of this suture is closed by the tympanic plate of bone except immediately external to the drumhead. The furuncle-like lesion results when the suppurative process extends through this<sup>o</sup> portion of the suture. This lesion is frequently considered a local cutaneous lesion, and the adjacent pathologic change in the bone is overlooked. Sagging of the posterior-superior canal wall is present when perforation of the skin does not occur.

Squamomastoiditis produces any combination of the aforementioned clinical signs.

## ROENTGEN FINDINGS

Radiologists are almost universally unaware of the important observations made by Korner and others. Roentgen changes due to involvement of the squamosal cells without disease of the petromastoid cell system are seldom correctly interpreted. The lateromedial depth of the cellular extensions between the outer and inner tables of the pars squamosa is but a small fraction of the depth of the cellular area in the mastoid process. The change in radiolucency caused by suppuration in cells above the linea temporalis is correspondingly less and is easily overlooked. Definite evidence of squamositis is often reported simply as clouding of the region of the antrum.

## SURGICAL CONSIDERATIONS

The accepted technics of simple and radical mastoidectomy do not remove diseased bone in the well pneumatized pars squamosa. After the mastoid cavity has been exenterated, temporal bones of this type require removal of the outer table of the pars squamosa above the linea temporalis and in an anterior direction to the limits of cellular extension. If the original incision is postauricular, it must be prolonged



upward and forward, in many cases beyond the anterior attachment of the auricle. The bony superior canal wall is frequently several millimeters from the floor of the middle cranial fossa, and the intervening region may be occupied by diseased cells. In this region adequate exenteration necessitates that the skin of the external auditory meatus be retracted downward and the bony superior canal wall removed in order to afford access. If preservation of the ossicular chain of the middle ear is intended, the innermost portion of the scutum of Leidy with its attached membrana tympani is left intact. However, the lateral wall of the epitympanum should be removed. This can be accomplished without dislodging the ossicles. When the pars squamosa, as well as the mastoid process, is exposed, the procedure is correctly called squamomastoidectomy. In mastoidectomy performed in the presence of



Fig 4—Roentgenograms of the mastoid processes. The left (in the right circle) is normal. The right demonstrates clouding and destruction of cells of the pars squamosa. The cells of the mastoid portion of the pars petrosa are slightly clouded but otherwise normal. The pathologic condition cannot be called mastoiditis, since the mastoid process is practically normal. The pathologic involvement is in the pars squamosa and can properly be termed squamositis.

squamositis, neglect of the pars squamosa can lead to continued aural discharge and even petrositis or intracranial complications. In only a small percentage of cases do the anatomic limits of the mastoid process represent the limits of pneumatization and disease. Therefore squamomastoidectomy is the indicated conservative operation in most cases of so-called mastoiditis.

#### SUMMARY

The primary purpose of this paper is to emphasize the existence and significance of the clinical entity squamositis. Because of the peculiar anatomy and a failure to recognize changes in the roentgen films, disease of the pars squamosa is frequently overlooked.

Disease of the temporal bone, hitherto loosely designated as mastoiditis, has been analyzed and divided into the following three clinical entities (1) squamomastoiditis (the commonest clinical form), which is disease of the pneumatic cells of both the petromastoid and the squamous bone, (2) mastoiditis, disease of the cells of the petromastoid bone alone, (3) squamositis, disease of the cells of the pars squamosa alone

An anatomic explanation is given for the clinical phenomenon of sagging of the posterior-superior wall of the external auditory meatus and for a furuncle-like lesion in that region

A fourth point of tenderness has been described—in the supra-auricular region

Since the air cell complex of the pars squamosa is largely outside the mastoid process, the complete surgical exposure should be squamo-mastoidectomy rather than the conventional mastoidectomy alone

Dr W F Whelan permitted me to study the bipartite temporal bone in his collection Dr O V Batson made many helpful suggestions with respect to the preparation of this paper

713 Union Street

# Case Reports

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## EPISTAXIS

### Report of a Case of Ligation of the External Carotid and Anterior Ethmoid Arteries

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AND

J C RISHER, M D

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IN THE past ten years many patients with epistaxis secondary to various conditions have been treated in the department of otolaryngology at the University of Virginia Hospital. The external carotid and anterior ethmoid arteries have been ligated in individual patients, but not until this incident had both been ligated in the same patient to control nasal hemorrhage.

According to Schaeffer,<sup>1</sup> the main intranasal blood supply is from the sphenopalatine artery. The ethmoid and palatine arteries, in addition, contribute to the vascularization of the nose to a lesser degree. From these facts, it is reasonable to assume that in the majority of cases severe epistaxis would be controlled by ligation of the external carotid artery.

The case which we report is that of a patient suffering from severe epistaxis, with hypertension and arteriosclerosis being the causative factors. The external carotid artery was first ligated after the usual local measures were of no avail, and with no success. Hemorrhage was then completely controlled with the additional ligation of the anterior ethmoid artery.

#### REPORT OF CASE

W S B, a 67 year old white man with hypertension and arteriosclerosis, had suffered no hemorrhage until the night of April 13, 1948. He was awakened by profuse epistaxis, which persisted and required admission to the local hospital. There his nose was packed, and he was given a blood transfusion. The hemorrhage persisted with great severity at intervals, so that on April 16 he was transferred to the University of Virginia Hospital.

On admission the patient exhibited the signs and symptoms of loss of blood, the blood pressure was 110 systolic and 60 diastolic (previously it had been 200 plus systolic and 100 plus diastolic), the red blood cell count was 2,760,000, the hemoglobin content was 7 Gm per hundred cubic centimeters, and the sensorium was cloudy. The nasopharynx and nasal cavities contained the limit of gauze and cotton packing. There was still slight but steady bleeding into the pharynx. Any effort to remove the packing to examine the nose resulted in massive hemorrhage, accompanied by early signs of shock. Before leaving the admission room, it was necessary to give the patient 3 units (each 500 cc) of blood.

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1 Schaeffer, J P. The Nose and Olfactory Organ, P. Blakiston's Son & Co., Philadelphia, 1920 pp 275-278

From April 16 to April 19 the hemorrhage persisted in spite of all efforts to control it. At no time could the exact site of bleeding be determined except that the blood was from the left side. Reasoning that such profuse bleeding could have its origin only from the sphenopalatine artery, we ligated the external carotid artery on the afternoon of April 19. Following this procedure, there was still slight bleeding. However, on April 22 all packs were removed. Within twelve hours hemorrhage occurred as before. The anterior and postnasal packs were reinserted. Blood transfusions were again necessary and were given. As the bleeding persisted and the situation remained critical, on Sunday afternoon, April 25, the anterior ethmoid artery was ligated. Following this procedure, active bleeding ceased, and all packs were removed on April 28. Progress thereafter was satisfactory, and the patient was discharged from the hospital on May 6.

At the time of writing, the patient has been under observation as an outpatient for six months, and there has been no epistaxis. The trauma to the mucous membrane of the nose from the packing has subsided. Roentgenologic examinations of the sinuses have shown that previous haziness in the left antrum has cleared.

The patient was given a total of 5,750 cc of whole citrated blood, vitamin B complex,<sup>2</sup> ascorbic acid and vitamin K in large quantities and calcium intravenously. Oxidized cellulose gauze and plain cotton were used as nasal packs. The coagulation and bleeding times, the prothrombin level, the smears and the differential counts were within the limits of normal.

#### COMMENT

On many occasions in the procedure for external exenteration of the ethmoid cells we have ligated the anterior ethmoid artery on the orbital side just as it enters the roof of the nasal cavity. We have never been impressed with the size of this vessel or the volume of blood carried by it. In this particular case, the vessel was not unusual, but apparently it must have been the main source of the severe epistaxis.

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<sup>2</sup> Betalin-Lilly was used, containing 10 mg thiamine hydrochloride, 4 mg riboflavin, 150 mg nicotinamide, 5 mg pantothenic acid (as calcium pantothenate) and 10 mg pyridoxine hydrochloride.

## Abstracts from Current Literature

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### Ear

THE PRESENT STATUS OF SURGERY OF THE EAR L GARCIA IBANEZ, *Rev españ de oto-neuro-oftal*, (September-October) 1947

Garcia Ibanez toured various medical centers in the United States and reported his observations on the present day status of surgical treatment for deafness. Following are his conclusions. Otosclerosis is a bony dystrophy of the labyrinthine capsule which when it involves the circumference of the oval window produces a bony ankylosis of the stapes, resulting in a conductive type of deafness. Because of its progressive nature and unknown cause, there has not been any satisfactory medical treatment. Fenestration of the labyrinth with a modern perfected technic is the only treatment which has given positive and permanent results in an increasing percentage of selected cases. The ideal case for the fenestration operation is that of a young person with otosclerosis who has a normal tympanic membrane and clearcut signs of ankylosis of the stapes, whose audiogram shows a loss of air conduction of more than 30 decibels or less than 70 decibels within a conversational range and in whom the bone conduction does not show a greater loss than 30 decibels in the same frequencies. The nasal fossa should be normal and the eustachian tubes patent, and there should be no evidence of infection or allergy. On the other hand, a number of good results have been obtained in cases which deviate from the limits of the so-called ideal one. Permanent results are attained in 60 per cent of the cases if the return of practically normal hearing is considered, if decided improvement in hearing is considered, the results may reach 89 per cent. The vital risk is negligible. Facial paralysis was found to occur once in 150 cases. With the modern technic postoperative closure of the fenestration has been reduced to 5 per cent and traumatic serous labyrinthitis to 1 per cent. This technic has exacting requirements: (1) wide experience with the dry bone and the cadaver, (2) a perfect technic with the proper endaural surgery, the electric drill and operation under magnification, (3) perfect surgical equipment, (4) a perfect surgical team in the operating room. This type of operative procedure is the most difficult of the specialty, yet it is the most revolutionary in the present century.

PERSKY, Philadelphia

### Larynx

A FOREIGN BODY FATALITY CHARLES C WOLCOTT, *New York State J Med* 48 309 (Feb 1) 1948

Wolcott warns that to diagnose the presence of a foreign body is not always easy, even by means of roentgenograms. Inflammation and infiltration may becloud the foreign body, so that the shadow remains undiagnosed. A nonopaque object may disclose its presence by producing an obstructive emphysema if it prevents the escape of air on expiration, or an atelectasis if it prevents the by-passage of air on inspiration. "It is imperative that roentgen examination be made at the beginning and end of respiration." If one detects a wheeze, best heard through an open mouth, the presence of a foreign body may be suspected, though it may produce no symptom.

The author presents a case of an 11 month old boy who had swallowed an open safety pin, unknown to any one. On the third day thereafter, emesis developed, followed by refusal of food and a moderate rise in temperature. On the fourth day there were chills, emesis and fever, and the child's condition was mistaken for pneumonia and congenital heart disease. On admission to Grasslands Hospital, the patient was moribund, with a temperature of 103.4 F. Roentgen examination showed a large open safety pin at the lower end of the esophagus, but by the time an esophagoscope was introduced it was no longer there. The following day the child died. Autopsy showed that the pin had lacerated the esophagus in two places and had passed through the mediastinum into the pericardial sac. The pericardial cavity contained 150 cc of cloudy, gray fluid and many fibrin clots. Cultures of the pericardial fluid and of the blood obtained post mortem showed the presence of *Staphylococcus aureus*. The author emphasizes the importance of early roentgenographic study in all cases of obstruction of obscure cause.

Voorhees, New York

### Nose

THE ETIOLOGY, TREATMENT AND PREVENTION OF CHRONIC SINUS INFECTION  
S J CROWE AND JAMES E LETT, *Ann Otol, Rhin & Laryng* 57 364  
(June) 1948

Pyogenic bacteria are present in the nasopharynx from infancy to old age. Repeated infections with the virus of the common cold facilitate the distribution of bacteria in the nasopharynx and prepare the soil for widespread outbreaks of disease of the respiratory tract. The cold virus enters the nose and is carried to the nasopharynx, where it lodges in the crypts and folds of the lymphoid tissue, penetrates the lining epithelium, breaks down cell membranes and protective barriers and thus provides a portal of entry for the bacteria which are always present in this area. A cellulitis develops, bacteria increase, the resulting edema causes obstruction of the nasal passages or eustachian tubes, and an acute sinusitis or otitis media ensues. When a terminal bronchus is occluded by a similar process, it is reasonable to assume that a condition results there similar to that in the aforementioned structures. In the ear and sinuses it is possible to establish drainage by surgical measures, and in the bronchus, by bronchoscopy and point suction. If these measures are taken to insure drainage in the course of the infection before extensive cellular destruction and granulations have formed, it is possible to prevent chronic infections of the ear and sinuses and it should be possible to prevent chronic suppurative bronchitis. The lymphoid nodules were found in the nasopharynx, in and about the eustachian orifice, near the posterior ends of the middle turbinate bodies and on the posterior and lateral surface of the Vomer. These nodules have crypts, and, though the size of the nodules is not important, the location is. Adequate irradiation will shrink the nodules and flatten and obliterate the crypts so that no favorable places remain in which the virus can lodge long enough for it to enter cells.

The mucosa of the ears and nasal sinuses has a remarkable ability to recover from a single or an occasional infection, but if infections are often repeated they become chronic, necessitating radical operative procedures. The only known way of preventing this is to examine the nasal passages and nasopharynx after an acute infection has subsided, and, if hyperplastic or chronically inflamed lymphoid nodules are found, to use surgical measures or irradiation or both.

The discussion on treatment of acute sinusitis is limited to the frontal sinus. A series of patients admitted to the hospital with acute symptoms were given penicillin intramuscularly and, if pain was severe, were promptly operated on. If pain was less severe, they were given both penicillin and sulfamerazine U S P, and heat and vasoconstrictors were used locally. For 16 of 104 patients, the conservative treatment was sufficient, in the others, a  $\frac{1}{2}$  inch (1.27 cm) incision was made through the unshaven eyebrow, just above the inner canthus of the eye, down to the bone. An opening  $\frac{1}{8}$  inch (3 mm) in diameter was then made into the sinus with a perforator and a burr, care was taken not to traumatize with retractors or clamps. The contents of the sinus were carefully aspirated after incision of the mucosa, which usually bulges into the wound. Care was taken not to injure further the tissues, and no effort was made to probe the nasofrontal duct. The cavity was filled with penicillin (1,000 units to the cubic centimeter of saline solution) or with tyrothricin suspension (1 cc of the stock solution in 25 cc of distilled water). A soft rubber tube was inserted for twenty-four hours, after which the sinus was gently irrigated with warm saline solution once a day. The margins of the wound were painted with phenol to prevent too early closing. The authors have had no cases of complicating osteomyelitis or cellulitis during the several years that they have used this method.

M. V. MILLER, Philadelphia

STREPTOMYCIN USED LOCALLY IN THE CARE OF CHRONIC SUPPURATIVE MAXILLARY SINUSITIS. REPORT OF A CASE. NATHAN L. FINEBERG, Laryngoscope 58 545 (June) 1948

The author discusses a maxillary sinus which had been badly infected for ten months. The culture showed gram-negative bacilli, irrigation with penicillin was not successful, but instillations of streptomycin every twenty-four hours cured the condition in three days. Infection with gram-positive organism followed, this was relieved by instillations of penicillin. Fineberg emphasizes the importance of this therapy and believes that it may often obviate the necessity of a Caldwell-Luc operation.

HITSCHLER, Philadelphia

NASAL SINUS DRAINAGE. FURTHER BERNOULLI EXPERIMENTS. Z. WILLIAM COLSON, Laryngoscope 58 642 (July) 1948

The application of the Bernoulli principle to nasal physiology is a comparatively new and important one. The author presents further reasons to confirm this principle and additional experiments to illustrate it. Colson's previous publications have more information on this subject.

HITSCHLER, Philadelphia

### Miscellaneous

PRIMARY STREPTOCOCCUS VIRIDANS MENINGITIS. STANLEY A. KORNBLUM, CHARLES ZALE and IRVING W. ROBINSON, New York State J. Med. 47 1387 (June 15) 1947

A 16 month old white boy entered the pediatric service of Morrisania City Hospital, New York, on February 28, and died on April 6, 1946. Fourteen days before admission the child had a running nose, which cleared spontaneously. Repeated cultures of the blood, urine, stool and material from the throat were all

sterile. No organisms were present in the spinal fluid. Blood chemical studies were all normal. *Streptococcus viridans* was recovered from the meninges at autopsy. Cultures and smears of the spinal fluid yielded no organisms, the temporal bones revealed no gross evidence of infection. A greenish exudate covered the base of the brain so completely that none of the cranial nerve origins or arteries could be seen without dissection. The exudate extended from the optic chiasm to the medulla and had grown over the roof of the fourth ventricle and the inferior surface of the cerebellar lobes. Both lungs showed terminal bronchopneumonia. The authors, in summary, state that this case was one of primary *Streptococcus viridans* meningitis which followed an infection of the upper respiratory tract. Details concerning the agents used were not given. Clinically, it resembled tuberculous meningitis because of its chronicity, the failure to isolate any organism, equivocal findings in the spinal fluid and lack of response to chemotherapy.

Voorhees, New York

THE PRESENT STATUS OF STREPTOMYCIN JOHN WINSLOW HIRSHFIELD and  
CHARLES W BUGGS, New York State J Med 47 1276 (June 1) 1947

Working in the laboratories and clinics at Cornell and Wayne universities, at Ithaca, N Y, and Detroit, respectively, the authors appraise streptomycin, introduced by Schatz, Bugie and Waksman in January 1944. The name was taken from the generic name of the organism that produces it, *Streptomyces griseus*, a soil actinomycete, which possesses a powerful antibiotic action to gram-negative and gram-positive organisms and is equally effective against *Mycobacterium tuberculosis*, in vivo and in vitro. Studies of its absorption, distribution and excretion in man after oral and parenteral administration have helped to establish dosage schedules and to prove that it is relatively nontoxic. However, bacteria have been able to develop resistance to streptomycin very rapidly when exposed to sublethal concentrations, therefore, large initial doses must be employed. The toxic effects of this drug are manifest in undesirable reactions of the skin and of the eighth cranial nerve.

Streptomycin has proved to be strikingly effective in the treatment of tularemia, many bacteremias due to gram-negative bacilli, infections of the urinary tract due to susceptible organisms, infections with Friedlander's bacillus and infections caused by *Hemophilus influenzae*. Its place in the treatment of brucellosis, tuberculosis (including the miliary type) and infections such as peritonitis and suppurative pulmonary disease has not been determined. The authors cite seventy-nine references to articles already published.

Voorhees, New York

ROLE OF THEPHORIN PHENINAMINE TARTRATE IN ALLERGIC DISORDERS H HAROLD  
GELFLAND, New York State J Med 48 1947 (Sept 1) 1948

Gelfland states that some allergists still do not fully accept the histamine theory of allergy. However, antihistamine drugs have given relief clinically. Tripeleannamine hydrochloride (pyribenzamine®) and diphenhydramine (benadryl®) cause many side reactions, but pheninamine tartrate (thephorin®) has fairly good tolerance. The patient, instead of being drowsy, is wakeful at night, but this can be overcome by sedatives or soporifics. An unselected group of 129 patients having various allergies was taken for a test of pheninamine tartrate. The daily dosage was 50 to 100 mg, usually 75 mg. Children received 5 to 40 mg. The drug can be administered for several months without changes in the characteristics of the blood. Of 22 cases of bronchial asthma, improvement



was seen in 59 per cent, and of 64 cases of seasonal hay fever, benefit was recorded in 45.3 per cent. Perennial rhinitis was partially relieved, but no relief was obtained in 5 cases of angioneurotic edema.

The author concludes that pheninamine tartrate has definite histamine-antagonizing qualities—it is an adjuvant to other antiallergic therapy, does not cause drowsiness during the day and can be continued for months if necessary. The effect lasts three hours, not longer. Temporary relief is all that can be had from any of these “newer remedies.”

Voorhees, New York

TUBERCULOUS MENINGITIS COMPLICATED BY PREGNANCY E. G. SILVERMAN and  
T. M. FEINBLATT, New York State J. Med. 48:2280 (Oct. 15) 1948

The authors report that a search of the literature revealed no case of tuberculous meningitis treated by streptomycin with delivery of a healthy baby and subsequent recovery of the mother. Sixty-five cases were reviewed, 36 of men and 29 of women. The ages averaged a little over 26 and ranged from 14 months to 67 years. In 36 cases the spinal fluid revealed *Bacillus tuberculosis*, in 30 cases diagnosis was not immediately confirmed, but in 10 of these it was verified at autopsy. In the remaining 20, the clinical diagnosis was presumptive. Six patients were treated with streptomycin. The patient reported on in the article is the only survivor. The average period of survival was 66.8 days.

The otologist will be interested chiefly in the otologic examination. Both auditory canals and ear drums were normal, with no tenderness in the mastoid bone. In the Weber test hearing was lateralized to the left. The Rinne test disclosed that air conduction was greater than bone conduction in both ears. The Schwabach test showed that bone conduction was diminished about one half bilaterally. The vestibular function showed no spontaneous nystagmus. The caloric test with ice water, 40 cc. in fifteen seconds, caused no response in either ear. “The impression was of impaired hearing and vestibular function, central type, caused by basilar meningitis and streptomycin reaction.” The streptomycin levels ranged from a high of 31 to a low of 1 unit per cubic centimeter, the blood level ranged from a high of 16 to a low of 4 units per cubic centimeter. On Aug. 20, 1948, eight months after leaving the hospital, the patient and baby were alive and well. A total of 315 Gm. of streptomycin was administered intramuscularly over one hundred and five days, a total of 15.4 Gm. was given intrathecally over seventy-two days.

Voorhees, New York

SPHENOPALATINE GANGLION BLOCK FOR THE RELIEF OF PAINFUL VASCULAR AND  
MUSCULAR SPASM WITH SPECIAL REFERENCE TO LUMBOSACRAL PAIN  
J. LEWIS AMSTER, New York State J. Med. 48:2475 (Nov. 15) 1948

Amster read this essay before the annual meeting of the Medical Society of the State of New York, on May 19, 1948. He says that when one speaks of the autonomic nervous system one often overlooks the four sympathetic cephalic ganglions, namely, the sphenopalatine, ciliary, otic and submaxillary. Sluder was probably the first to call attention to the therapeutic value of anesthetizing the sphenopalatine ganglion for the relief of intractable pain, he reported “cures” so remarkable that many were incredulous. Ruskin, Neuberger and others revived the procedure. Amster reports 103 cases, with relief of pain in 90 per cent, some of them after only one “block.” In the chronic cases with

sacroiliac distress, for example, several sittings were required. In about 10 per cent there was no relief, probably because of deep-seated organic trouble with irreversible pathologic changes.

Four figures are used to illustrate the anatomy and the method of application of tetracaine, monocaine, or a similar anesthetic. Amster no longer uses cocaine. A table of "conditions treated" covers such items as migraine, persistent hiccup, intercostal neuritis, dysmenorrhea and ureteral colic. It was brought out in the discussion that the sympathetic nervous system is little understood from a medical standpoint, although the anatomy seems well described in such texts as the twenty-fifth edition of Gray's "Anatomy." The functional relation to diseases in the broad sense is still in the guessing stage. Here is a field for action where a young enthusiast may immortalize his name.

Voorhees, New York

A GUIDE TO THE USE OF PROCAINE PENICILLIN IN HOSPITAL PRACTICE. GENE H. STOLLERMAN, EDWARD H. ROSTON and BEATRICE TOHARSKY, New York State J. Med. 48:2501 (Nov. 15) 1948.

Working at the Mount Sinai Hospital (New York), the authors have drawn interesting comparisons between penicillin G and the procaine salt of penicillin. The former has been useful when given orally in pediatric practice, but its fate in the gastrointestinal tract is uncertain. About five times as much is required when the drug is given orally as when administered parenterally. Penicillin in oil and white wax U. S. P. (Romansky formula), given in doses of 300,000 units intramuscularly, holds a blood level for twelve hours. The advantages are obvious. Procaine penicillin G in oil gelled with aluminum monostearate may hold the blood level for ninety-six hours, or longer! It is assumed that the drug particles become water repellent. These suspensions in oil are stable and do not require refrigeration. But the syringe and needles must be made fat free after use by cleansing with detergents or fat solvents. Certain principles are to be observed: 1. The germs must be penicillin sensitive. If not, 600,000 units must be given daily (twice the ordinary dose). If aluminum monostearate is used as a detergent to eliminate spacing, may be one day, or even several days, apart, the interval depending on factors present in a given case. 2. Daily determinations of the blood level are no longer imperative, but identification of the bacterium and its sensitivity to whatever agent is employed is highly important. One must know the enemy! 3. The stock bottle must be shaken thoroughly. A 20 gage needle is inserted into the bottle, fluid is withdrawn, and the site is chosen. The needle is inserted into the muscle (buttocks), care being taken to avoid blood vessels (embolism) and to get deep below the fat. The plunger must be pressed promptly, or the needle will clog. (Cleansing of the hypodermic outfit after use has already been mentioned.) 4. Therapeutic response must be the chief guide to further administration, size of dose and interval of injections. 5. Single dose therapy has been tried, but relapses have been noted. 6. Syphilis and gonorrhea yield to the procaine penicillin, but treatment of the former is still *sub judice* with respect to dosage and length of treatment required. Ten days has been regarded sufficient for syphilis, 300,000 units being administered daily or on alternate days, as seems necessary. As for gonorrhea, "a single injection of 300,000 units of procaine penicillin with or without aluminum monostearate should be adequate for the cure of gonorrhea!" 7. Subacute bacterial endocarditis can be treated with 600,000 units given once a day for

six to eight weeks, but the duration of treatment cannot be shortened by increasing the dose. *Streptococcus viridans*, when found, may prove resistant over a period of weeks. 8 Prophylaxis before, during or after surgical procedures calls for administration of 300,000 units daily, according to conditions. (Tonsillectomies and dental extractions are mentioned.) 9 Crystalline penicillin G now has relatively few indications as against procaine penicillin. The latter seems to have no cumulative or disturbing effects, the only possible toxicity might come from too much procaine being released. Moreover, procaine may limit the action of the sulfonamide compounds, therefore, crystalline penicillin is to be preferred when one proposes to use the sulfonamide drugs synchronously. Crystalline penicillin is required for topical applications. It is also the agent to be combined with aerosol preparations for use in the antrum or the buccal cavity.

The article is an excellent one and deserves wide reading.

VOORHEES, New York

HYDROLYZED ORAL HAY FEVER ANTIGENS. HENRY M. FEINBLATT and EDGAR A. FERGUSON JR., New York State J. Med. **48** 2720 (Dec 15) 1948.

Oral treatment of hay fever with pollen extracts dates from 1922. Hitherto, gastrointestinal reactions have made it unfavorable, but with a process of pollen hydrolysis, this objection disappears. The authors give the formula for mixing these hydrolyzed pollens found effective in most cases. Tablets were made containing 10 mg. each, plus ordinary excipients, one 10 mg. such tablet may be taken as a test dose. If no untoward symptoms develop, the dose may be increased daily by 1 tablet until a maximum of 10 per day are taken. The usual dose is 2 tablets three times a day. The authors discuss the chemistry of allergens and include a table showing examples of hydrolysis. The purpose of the clinical series was to determine the therapeutic effectiveness of tablets of hydrolyzed mixed ragweed and common pollen and the incidence of gastrointestinal irritation and untoward reactions of an allergic nature caused by this medication. The groups consisted of unselected subjects ranging in age from 7 to 59. The chronicity of allergic rhinitis was evident in the average duration of the complaint, which was nine and three-tenths years. In summary, the index of benefit was 78 per cent for oral antigen therapy, but only 44 per cent for injectable antigen therapy. The percentage decrease in days lost from work was 78 per cent with oral antigen therapy and 25 per cent with the injectable antigen. No instance of gastrointestinal irritation was found with oral administration of antigen. These percentages were based on a series of 35 subjects observed over an average of five years.

VOORHEES, New York

## Book Reviews

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**Plastic Surgery of the Nose** By Albert P Seltzer, M D , M Sc (Med ), Sc D , Associate in Otolaryngology, Graduate School of Medicine, University of Pennsylvania Price, \$12 Pp 305, with 221 illustrations, including 7 plates in color Philadelphia J B Lippincott Company, 1949

The history of plastic surgery is well set forth in the first chapters of this volume, and the antiquity of this field is revealed in the discussion of the amazing work of the ancients, who labored without any "tools of the trade," of which anesthetics may especially be noted In general, the principles of this art have been well set since the turn of the twentieth century, and they do not vary notably Every operator has certain favorite methods, but these are subordinate to well established technics The most illuminating chapter in this book is the nineteenth, which deals with "The Unsuccessful Operation—Its Causes and Prevention" Common surgical errors result from the doing of too much or too little, a failing of essentially all human beings, and not of surgeons alone The author allows for this, and concludes that " the most important factors for success are observation and experience"

**Phylogeneses of the Ear** By Louis Guggenheim, M D Price, \$12 50 Pp 266 Hollywood, Calif Murray & Gee, Inc , 1949

This book is an erudite and academic classic It gives tremendous detail on the history and growth of the structure of the ear throughout the animal scale Going back three or four hundred million years to examine the hearing apparatus in fossil layers, as the author does, is starting a priori, to be sure The many beautiful illustrations, with their carefully written captions, make this book a veritable storehouse for anyone interested in comparative anatomy It was interesting to learn that the cochlea of the cat and dog has three turns and that these animals hear much better than man, but why should the cochlea in the lowly pig have four turns?

This volume is indeed worth while reading for all otolaryngologists, and should be compulsory reading for the graduate student in this specialty

# Directory of Otolaryngologic Societies \*

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President Dr V E Negus, London, England  
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Place London Time July 18-23, 1949

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## NATIONAL

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## ROLE OF ALLERGY IN THE EPIDEMIOLOGY OF THE COMMON COLD

NOAH FOX, M D

AND

GEORGE LIVINGSTON, M D

CHICAGO

ALTHOUGH the virus is generally accepted as the causative organism of the common cold, much obscurity exists concerning the role of contributory factors, such as exposure to cold, fatigue and debility. These elements of one's environment have been much discussed in the literature, so that only a brief résumé will be necessary here. The purpose of this paper, however, is to suggest another factor, allergy, which will be discussed in relation to factors already known.

### THE CASE OF EXPOSURE TO COLD

Since time immemorial, chilling has been considered a factor in the pathogenesis of the common cold. The Germans express this thought in the term *Erkaltung*. Certain investigators<sup>1</sup> had noted changes in the nasal mucosa of persons exposed to heat and cold, but none of these investigators produced laboratory evidence of these changes until Mudd and his associates<sup>2</sup> published their work. They then showed that cutaneous chilling causes a reflex sympathetic motor stimulation, resulting in depression of the temperature of the nasal mucosal surface through vasoconstriction and diminution of blood supply. They also recorded a number of colds and sore throats occurring among the subjects of the experiment. Ralston and Kerr<sup>3</sup> were unable to find any systemic differences between normal and hypersensitive patients as regards changes in nasal temperature in response to cold or hot.

From the Department of Otolaryngology, Rhinology and Laryngology, University of Illinois College of Medicine

<sup>1</sup> Hill, L., and Muecke, F. F. Colds in the Head and the Influence of Warm Confined Atmospheres on the Mucous Membranes of the Nose and Throat, *Lancet* **1** 1291, 1943. Schade, H. Untersuchungen in der Erkaltungsfrage, *Munchen med Wchnschr* **66** 1021, 1919, **67** 449, 1920.

<sup>2</sup> Mudd, S., Grant, S. B., and Goldman, A. Reactions of the Nasal Cavity and Postnasal Space to Chilling of the Body Surface. I. Vasomotor Reactions, *J Exper Med* **34** 11, 1921.

<sup>3</sup> Ralston, H. J., and Kerr, W. J. Vascular Responses of the Nasal Mucosa to Thermal Stimuli, with Some Observations on Skin Temperature, *Am J Physiol* **144** 305, 1945.

stimuli, though Spiesman<sup>4</sup> reported that the very frequently infectious head cold presents a much delayed reaction to a cold stimulus. This and subsequent investigations of a similar character<sup>5</sup> comprise the experimental evidence that chilling plays a part in the genesis of the common cold. The mechanism thought to be involved is an altering of the local resistance by this chilling which allows the virus to multiply. However, no experimental evidence exists at this time to warrant the assumption that faulty function of the heat-regulating center of the body is responsible for susceptibility to infection of the upper respiratory tract. In no case in which investigators have succeeded in transferring the common cold to other persons or animals<sup>6</sup> has a chilling mechanism been involved, and, as a matter of fact, Powell and associates<sup>6b, c</sup> purposely carried out most of their experiments during the summer months.

Numerous studies have been made both in large population centers and in isolated communities to determine the relationship of weather and exposure to the common cold.<sup>7</sup> Except for some differences in the secondary invaders there is a close similarity of cases of the disease, whether it occurs in Greenland, Spitzbergen, Labrador, Alabama or in the Virgin Islands. Characteristically, all investigators reported similar observations, namely, complete freedom from colds, irrespective of the season, until some person made contact with the outside world and returned to the community with a cold.<sup>7b, c</sup> Characteristic, also, was the observation that once a cold occurred in these isolated communities which are normally free from colds, almost every person in the community acquired a cold, irrespective of the time of the year,

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4 Spiesman, I. G. An Experimental and Clinical Study of the Common Cold, *Ann Otol, Rhin & Laryng* **50** 204, 1941.

5 Spiesman, I. G., and Arnold, L. Host Susceptibility to Common Colds, *Am J Digest Dis* **4** 438, 1937. Ralston and Kerr.<sup>3</sup>

6 (a) Kruse, W. Die Erreger von Husten und Schnupfen, *Munchen med Wchnschr* **61** 1547, 1914. (b) Powell, H. M., and Clowes, G. H. A. Cultivation of the Virus of Common Cold and Its Inoculation in Human Subjects, *Proc Soc Exper Biol & Med* **29** 332, 1931. (c) Dochez, A. R., Shibley, G. S., and Mills, K. C. Studies in Common Cold. IV. Experimental Transmission of Common Cold to Anthropoid Apes and Human Beings by Means of a Filtrable Agent, *J Exper Med* **52** 701, 1930. (d) Powell, H. M., Sparks, A. L., and Clowes, G. H. A. Further Inoculation-Experiments with the Common Cold Virus, *J Immunol*, **38** 309, 1940.

7 (a) Heinbecker, P., and Irvine-Jones, E. L. M. Susceptibility of Eskimos to the Common Cold and Study of Their Natural Immunity to Diphtheria, Scarlet Fever and Bacterial Filtrates, *J Immunol* **15** 395, 1928. (b) Paul, J. H., and Freese, H. L. Epidemiological and Bacteriological Study of the "Common Cold" in an Isolated Arctic Community (Spitzbergen), *Am J Hyg* **17** 517, 1933. (c) Burky, E. L., and Smillie, W. G. Nasopharyngeal Flora in Health and During Respiratory Disease in Isolated Communities in Alabama and Labrador, *J Exper Med* **50** 643, 1929.

indicating almost a total lack of immunity, as one would expect under such circumstances. Yet it must be remembered that as fishermen these people are constantly exposed to cold and wet weather and are frequently immersed in cold water accidentally without suffering from colds.

Hill<sup>8</sup> stated

In spite of popular opinion to the contrary it is clear that exposure even to extremes of cold, by itself, does not occasion "colds" or pneumonia. Shipwrecked folk, exposed almost to that point of chilling which stops the vital functions, do not suffer from coryza or pneumonia, neither do the troops exposed to the severest hardships in the trenches.

Smillie<sup>9</sup> concluded from his studies of colds in Alabama, Labrador and the Virgin Islands that in every instance epidemics of colds followed a drop in atmospheric temperature. He found mild colds in the tropics, where the weather is mild, and severe colds in the temperate zone, where the drop in temperature may be severe.

Brown and associates,<sup>10</sup> in a report of their analysis of the day to day changes in the incidence of the common cold in a group of 600 college girls during the year 1942-1943, concluded that heavy rainfall accompanied by dropping temperature definitely increased the incidence of colds in the college population. These investigators found that a group representing 23 per cent of the students had 45 per cent of the total number of colds. They appraised the students by means of a modified Flack test but were unable to find any uniform deterioration in fitness during the progress of the year to account for increased susceptibility to colds.

Sargent,<sup>11</sup> in observing the incidence of colds at Phillips Exeter Academy, noted that the passage of a cold front brought on within two to three days a rise in incidence of the common cold extending over the period of dropping temperature.

Duffield<sup>12</sup> reported a definite increase in the number of colds following the passage of a cold front, especially when this was associated with precipitation.

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8 Hill, L. The Science of Ventilation and Open Air Treatment, Medical Research Council, Special Report Series, no 52, London, His Majesty's Stationery Office, 1919, pt 1, p 141.

9 Smillie, W. G. Observations on the Epidemiology of the Common Cold, New England J Med **223** 631, 1940.

10 Brown, W. B., Mahoney, F., Niedringhaus, A., and Locke, A. Weather and Susceptibility in Relation to the Spread of Common Cold. Effect of Ascorbic Acid, in Massive Dosage, on Duration, J Immunol **50** 161, 1945.

11 Sargent, F. Stability of Resistance to the Common Cold, Am J Hyg **45** 29, 1947.

12 Duffield, T. J. The Weather and the Common Cold, Am J Pub Health **19** 1, 1929.



Frost and Gover<sup>13</sup> reported on the incidence of colds from a large group of university students and families throughout the country. In spite of the wide dispersion of areas, there was a striking time correspondence in the cold epidemics of the years 1923 to 1926 and a uniformity of attack rate, indicating that climate is not an important epidemiologic factor.

#### THE CASE OF FATIGUE AND DEBILITY

Locke<sup>14</sup> worked out an exercise technic imposing a stress which would just reach a severe overload when responded to at the maximal possible rate. He measured the rate of oxygen use during the final minute of measured effort which he considered as within the range of crest load for the normal person and overload for the undernormal person. Persons with heart disease or with any disease of the respiratory tract were rejected. The subjects were all school children. Locke expressed the belief that the efficiency of resistance is determined by the response of man to exercise.

The investigations were made through inquiry as to the number of colds incurred by these persons, who were then divided into two groups, one comprising those reporting one cold or less for the season and the other those reporting two or three colds. More than two thirds of the persons reporting one cold or less for the season had oxygenation times between 0.56 and 0.62, those reporting two or three colds times below 0.59. The grade of the subjects tested for oxygenation time on the day of onset of a cold was below 0.59 regardless of whether the grade had been above this mark previously. Locke pointed out this susceptibility as augmenting the shock-precipitating mechanism of a specific causal agent, such as the virus. He noted that 69 per cent of a mixed group of persons with fitness rated above 0.6 of maximal reported one cold or less for the winter of 1935-1936. Eighty per cent of an equivalent group of 15 persons with fitness rated below 0.5 reported four colds or more for the same period (1937). Locke found that the following nonspecific factors caused a lowering of resistance in rabbits and hence impairment of ability to resist infec-

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13 Frost, W. H., and Gover, M. The Incidence and Time Distribution of Common Colds in Several Groups Kept Under Continuous Observation, *Pub Health Rep* **47** 1815, 1932.

14 Locke, A. Lack of Fitness as the Predisposing Factor in Infections of the Type Encountered in Pneumonia and in Common Cold, *J Infect Dis* **60** 106, 1937, Non-Specific Factors in Resistance. I Capacity to Sustain Effective Circulation, *J Immunol* **36** 159, 1939, IV The Problem of Common Cold, *ibid* **36** 365, 1939. Locke, A., and Main, E. R. Non-Specific Factors in Resistance. II Ability to Withstand Shock, *ibid* **36** 173, 1939. Locke, A. Non-Specific Factors in Resistance. V Carbon Dioxide Tolerance, *ibid* **36** 365, 1939.

tion shock, exposure to overheating, deprivation of food, fatigue from chilling, i e, shivering, circulatory failure from various causes, as drugs, shock injury, interference with oxygenation and water exchange, inanition, and endocrine deficiency. He concluded that fitness is a factor in resistance in that it "reflects adequacy of capacity for sustaining circulation which is essential for the efficient functioning of the defense mechanism."

Locke further developed a technic to measure the resistive efficiency of man, by having the subject inhale carbon dioxide for one to two minutes, which, he claimed, imposes a test emergency on the defense against suffocation, causing air increase in deep breathing. He worked out a ventilation quotient based on the ventilation rate, basal metabolic rate, and ventilation volume for a given number of respirations. He determined that a ventilation quotient of 1.29 may indicate a minimal predisposition to the common cold and that the susceptible person diverges from 1.29 more than 5 per cent.

Although Locke specifically stated that his results were obtained in patients free from allergy, we suspect that he means only frank allergies, i e, asthma, seasonal and perennial allergic rhinitis, eczema, etc. He noted a tendency toward hyperreaction to inhaled carbon dioxide in a group of patients suffering from allergic dermatitis, a condition expected in the hypersensitive person, though this group did not have a heightened susceptibility to colds. On the other hand, the more usual type of hyperreaction to carbon dioxide was associated with heightened susceptibility to the common cold.

In a survey of 5,000 students an attempt was made by Smiley<sup>15</sup> to study the factors commonly associated with susceptibility to colds. These included effects of warm clothing, tobacco, rest, exercise, diet, cold baths, constipation, heredity, etc. Of all the factors listed, he found that heredity might be important in determining resistance through carrying on to the next generation a catarrhal diathesis, or the opposite. He concluded that the major factor in susceptibility to colds is still a matter of conjecture but that there is an inclination toward the supposition that certain persons present a specific lack of immunity to the organism or organisms that cause colds.

Sargent,<sup>16</sup> in a four year study of the incidence of infections of the upper respiratory tract among Phillips-Exeter students, found a fixed incidence of colds each year for each student. He expressed the belief that some constitutional factor plays a significant role in deter-

<sup>15</sup> Smiley, D. F. Cold Susceptibles vs Normals. *Physique and Past Medical History*, *Am J Hyg* 9:473, 1929.

<sup>16</sup> Sargent, F., and others. Studies in the Meteorology of Upper Respiratory Infections, *Bull Am Meteorol Soc* 19:385, 1938, 20:141, 1940.

mining the incidence of colds and other infections of the upper respiratory tract

#### THE CASE OF ALLERGY

How is allergy related to these factors? It is common knowledge that allergic conditions are frequently initiated or exaggerated by a fall of temperature and increased humidity. The mechanism of this reaction is not clear but is thought to be related to increased permeability of the susceptible membrane, allowing the antigen to contact more readily its specific reagin in the cell.

Lurie<sup>17</sup> showed that resistance was associated with low cutaneous permeability as assayed by intradermal inoculation of india ink, increased rate and intensity of antibody response and development of a high degree of hypersensitivity.

There is a great deal of evidence that the common cold is an allergic response in susceptible persons to contact with a specific protein, which is the cold virus or its products.

Some of this evidence already exists in the literature, and some of it may be interpreted from reports which we quote.

Smiley,<sup>18</sup> in several surveys of college groups, came to the conclusion that most colds occur in a cold-susceptible group, the members of which present a history of more infectious disease, asthma and hay fever than normal students do.

Layton<sup>19</sup> noted that children frequently have cold after cold, winter after winter, for several years and then suddenly experience a cessation of this difficulty. He recalled that he was one of five children, two of whom, including himself, had frequent colds. He related that his colds ceased at the age of 12—a situation commonly seen in regard to allergic boys, about 50 per cent of whom lose the allergic tendency at puberty. He noted also that the other child, a sister who suffered from colds, suffered also from bronchitis, the entire picture suggesting an allergic background.

Coca,<sup>20</sup> in summarizing Locke's investigations, concluded that the latter's findings indicate that susceptibility to common cold is not due to a lack of the mechanism of defense but to a nonspecific impairment of the ability of the mechanism to function, resulting from a state of food sensitization. He found that 90 per cent of a group of 51 cold-susceptible persons were allergic to food. Of a group of 52 persons

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17 Lurie, M. B. Heredity, Constitution and Tuberculosis. Experimental Study, *Am Rev Tuberc (supp)* **44** 1, 1941.

18 Smiley, D. F. A Study of the Acute Infections of the Throat and Respiratory System, *J A M A* **82** 540 (Feb 16) 1924, footnote 15.

19 Layton, T. B. The Common Cold, *Practitioner* **154** 65, 1945.

20 Coca, A. F. Familial Nonreaginic Food Allergy as a Predisposing Cause of Common Cold, *J Lab & Clin Med* **26** 757, 1941.

who had no colds in the season studied, 31 had a family history of freedom from allergy to food, contrasted with 3 persons who had such a family history among the cold-susceptible group. Coca's explanation of the nonspecific factor of Locke is that it may be the effect of an allergic edema. He quoted Hoelzel,<sup>21</sup> McQuarrie<sup>22</sup> and Higgins,<sup>23</sup> who reported that the incidence of colds is reduced by restriction of carbohydrate consumption, the reduction being attributable to an observed lessening of tissue hydration.

Coca<sup>20</sup> added that there must be other predisposing causes of susceptibility besides allergy to food, because, although between 20 and 25 per cent of white families are free from such allergy, only 12 per cent are free from the common cold and a few of these are allergic to food.

Brown, Graham, Niedringhaus and Locke<sup>24</sup> made a study of 422 girls of Stephens College, Columbia, Mo., to evaluate the evidence reported by Coca for the existence of a cause and effect relationship between nonreaginic food allergy and the predisposition toward cold. They found that in 79 per cent of the group studied two or more of Coca's symptomatic evidences were present. They found a higher incidence of colds with an increasing number of symptoms.

Brown and Locke<sup>24a</sup> studied a group of women at Stephens College to determine the relationship of food allergy to colds. They noted particularly the relation of Coca's indicated allergic symptoms. Each of the eleven symptoms was associated, on the average, with a larger number of colds than was observed in the absence of symptoms. Furthermore, the number of colds increased directly and progressively with the number of symptoms present. That is, the greater the probability found for the presence of an underlying food allergy, the greater was the extent of predisposition toward common cold. One hundred and sixty-three of the students did not smoke and were in sufficiently good condition to pass the Flack fitness test. Of these, 36 had less than two of the accessory symptoms of nonreaginic food allergy, while 45 had four or more. The group with less than two symptoms had an average of 0.9 colds per person for the 1941-1942 season. The

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21 Hoelzel, F. Nutritional Edema and Its Relation to the Incidence of Common Colds, *Proc Soc Exper Biol & Med* **25** 454, 1928.

22 McQuarrie, I. Protein Metabolism of Children on Diets Extremely Low in Carbohydrates, *J Nutrition* **2** 31, 1929.

23 Higgins, H. L. Some Physiological and Clinical Effects of High Fat Feeding, *New England J Med* **203** 145, 1930.

24 Brown, W. B., Graham, I., Niedringhaus, A., and Locke, A. Non-Specific Factors in Resistance. VI. Incidence of Common Cold in Persons With and Without Accessory Symptomatology of Nonreaginic Food-Allergy, *J Immunol.* **46** 101, 1943.

24a Brown, W. B., and Locke, A. P. Fitness, Food Allergy and Predisposition to Common Cold, *J Missouri M A* **40** 99, 1943.

contrasted group had an average of 1.8. One hundred and one of the nonsmokers failed to pass the fitness test. Of these, the 17 with less than two symptoms had an average cold incidence of 1.4. The 30 with four symptoms or more had an average of 2.8.

The poor ability to maintain effective circulation and to withstand the effects of a sudden fall of temperature exhibited by the cold-susceptible patient is in keeping with the physical allergy so often noticed in allergic patients.

When Duke<sup>25</sup> first reported physical allergy, he believed this condition to be present only in people who were free of atopic allergy. However, further study of this condition has proved that observation to be false. Swineford<sup>26</sup> found in a study of 325 persons with atopic allergy that physical allergy was the chief or the aggravating cause in 201. Vaughan's<sup>27</sup> experience confirms this conclusion. In short, two thirds of all persons suffering from atopic allergies are sensitive to physical agents, as heat, cold and effort. Duke found early in his testing that, following the production of an allergic attack either with heat or cold, the patients were likely to contract an acute infection of the upper respiratory tract unless the reaction was promptly controlled by the application of the opposite thermal stimulus, and he expressed the belief that the tendency to repeated head colds or even pneumonia with change of season may be associated with allergy to heat or cold.

Bray<sup>28</sup> has shown that histamine is liberated in the skin of normal people when the temperature of the skin is decreased 20 F. In a case of cold allergy he found this threshold for the liberation of histamine raised 25 F.

The popular belief is that the common cold is initiated by chilling of the body, wetting of the feet or wearing of damp clothes. The response of the physically allergic person to these environmental factors may very well result in an outpouring of histamine into various shock centers throughout the body, particularly the respiratory tract, in sufficient quantity to destroy the local defense mechanism, preparing these tissues for acceptance of the virus of the common cold. Of course, the virus must be present. It is rather probable, however, that if such is the mechanism, secondary invaders will just as likely be

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25 Duke, W. W. *Urticaria Caused Specifically by the Action of Physical Agents (Light, Cold, Heat, Freezing, Burns, Mechanical Irritation and Physical and Mental Exertion)*, J. A. M. A. **83** 3 (July 5) 1924, *Physical Allergy Preliminary Report*, *ibid* **84** 736 (March 7) 1925.

26 Swineford, O., Jr. *Physical Allergy Its Role as Manifested in the Routine Study of Three Hundred and Twenty-Five Consecutive Allergic Cases*, J. Allergy **6** 175, 1935.

27 Vaughan, W. T. *Practice of Allergy*, St. Louis, C. V. Mosby Company, 1939.

28 Bray, G. W. *A Case of Physical Allergy*, Brit. J. Child Dis. **32** 45, 1935.

activated One does not frequently see colds in people suffering from seasonable hay fever, presumably because the virus is not abundant at this season There must be another factor which causes a person to be susceptible, irrespective of the condition of the nasal mucosa, and this factor must be tied up with the specific defense mechanism of the body In Spitzbergen, Greenland, Labrador and other places of observation, contact with the virus caused colds in 100 per cent of the members of the community This is similar to the observations made on apes by Dochez and co-workers<sup>26</sup> Dochez, in his animal experiments with colds, came to the conclusion that because chimpanzees could be reinfected as early as four weeks after recovery from a cold, immunity is nonexistent The chimpanzee entirely lacks immunity because in his natural environment he is not exposed to colds None of these persons or animals have nasal disease but lack immunity to this organism because of lack of previous contact In short, an antigen-reagin relationship is suggested which can be accounted for only by assuming that an individual's susceptibility to colds is predicated on that individual's allergy to a particular protein, which is the cold virus or material elaborated by this organism Obviously, where continuous infections take place, as they do in crowded communities, a person becomes less susceptible as he acquires more immunity through booster doses of antibody following mild infections, until a situation arises wherein some members of the community have none or only a few colds each year This is in accord with general principles of allergy and immunity

As with any allergic condition, a normal must be accepted Given a concentrated enough antigen, all persons can be made to react in an allergic manner, for the allergic response is one derived from quantity rather than quality It is easier to consider the cold-susceptible person as one who is allergic to a specific antigen (protein), which in his case is a virus

As Vaughan<sup>27</sup> has suggested, everybody is allergic to some degree The amount of allergy one develops depends on certain known factors, namely, the hereditary predisposition, the temporary permeability of the invaded tissue (which presumably may be influenced by fatigue, chilling, trauma, endocrine "let down," undernourishment, etc) and, finally, by the frequency with which one comes in contact with a particular protein A person is sensitized more easily to a foreign protein with which he establishes only occasional contact than to one with which the contact is constant The specific sensitivity may be due directly to the virus or to some substance elaborated by the virus, such as, perhaps, the Duran-Reynals factor<sup>29</sup> which increases the

<sup>29</sup> Duran-Reynals, F Tissue Permeability and the Spreading Factor in Infection Contribution to Host, Parasite Problem, *Bact Rev* 6 197, 1942

permeability of the respiratory membrane for invasion of the virus. The activity of the Duran-Reynals factor appears to be antigenic in that it is neutralized by antisera.

That no specific allergic antibodies are demonstrable in the blood of the cold-susceptible person or that passive transfer has been a failure is due to lack of precise methods by which to demonstrate these phenomena. No bacterial or infective allergy has ever been demonstrated as atopic. The evidence for allergy as a factor in colds rests on the finding that people susceptible to colds have other allergies and come from families in which allergies are present. In 1940 we<sup>30</sup> published under the title "Borderline Allergy" our concept of allergy as a pathogenic factor of common colds. This concept was based on a study of 1,200 cold-susceptible persons. Eighty per cent of these persons mentioned other allergies, present or past, or came from allergic families.

*Summary of Data Indicating Allergic Background of 3,140 Persons Subject to Common Cold*

Source	Total Number of Patients	Number with History of Other Clinical or Subclinical Allergies	Number with no History of Allergy But from Allergic Family	Number with no Personal or Family History of Allergy	Number with Hyperplastic Disease of Upper Respiratory Tract
University of Illinois Adults and children	600	366—61%	144—24%	90—15%	600—100%
Children's Memorial Hospital Children only	140	81—58%	31—22%	23—20%	140—100%
Private Practice Adults and children	2,400	1,680—70%	480—20%	240—10%	2,400—100%

This number has now been increased to over 3,000, representing persons of all ages and walks of life.

Our problem has been primarily that of immunizing cold-susceptible persons with a virus vaccine, and it has been in the selection of these subjects that the epidemiologic phase of this work has developed.

The table represents an attempt to group the patients on the basis of allergy of the patient, allergy of the family or both. It will be noted that statistics of private practice reveal a higher percentage of cold-susceptible persons to be allergic than do statistics of a dispensary. This is, of course, because more precise information can be obtained from persons of this stratum of society. The subjects in the Children's Memorial Hospital group have been under our observation continuously for the past five years. Among the 28 children classified as nonallergic in this group were a considerable number from whom satisfactory information could not be obtained. It is probable, therefore, that some

<sup>30</sup> Fox, N., Harned, J. W., and Peluse, S. Borderline Allergy. Its Relation to Hyperplastic Disease of the Respiratory Tract, *Arch Otolaryng* 31:502 (March) 1940.

of these were allergic. The University of Illinois group were principally adults. A slightly better history of allergy was obtained from them. Many of the private patients have been under our observation for periods as long as ten years, and during this time allergic diseases such as hay fever and urticaria have developed in those who previously had negative allergic histories. It should be noted further in the table that 100 per cent of the patients of all the groups have a common pathologic condition, namely, hyperplastic disease of the upper respiratory tract. Frequently allergy goes unnoticed because it is of the borderline or subclinical variety. The nose and the pharynx of the cold-susceptible patient must be examined to ascertain whether there are changes in the mucosal and lymphoid structures.

The most common pathologic change observed in the upper respiratory tracts of cold-susceptible people in temperate climates is hyperplasia of the aforementioned tissues of the upper respiratory tract, particularly along the airways of the nose, i.e., the middle and the inferior meatus. This may vary from mild thickening and deformity of the middle turbinate to the formation of large polypoid masses in these areas. Often the posterior tips of the lower turbinates are hyperplastic, revealing a mulberry or strawberry shape. In infants and children the lymphoid tissue throughout the pharynx and back of the tongue is greatly increased, and in adults it forms thickenings at the lateral edge of the pharynx opposite the posterior choanae and the back of the tongue. These people suffer constantly from postnasal drip and mouth breathing due to nasal intumescence, frequent sore throat from the postnasal drip, attacks of laryngitis, and stomatitis from mouth breathing. These symptoms are frequently bearable until during and following a cold, when they become annoying because so often secondary invaders cause an increase of infection and an exaggeration of the symptoms. The person with hyperplastic tissues highly susceptible to colds rarely has a cold lasting only four to five days. Almost invariably he gets a secondary infection of the sinuses lasting three to six weeks. Apparently, the mucosa must be injured specifically by the virus to cause these long colds. Surgical trauma of the nose of any of these same people, even though followed by the additional trauma of a pressure-producing pack, only rarely produces a secondary purulent pansinusitis such as is seen following a cold in highly susceptible persons. The mucous membranes of the allergic person seem always to harbor organisms, ready, when the proper stimulus occurs, to overgrow. In 1937 one of us (Dr. Fox) and Harned<sup>31</sup> reported the following experiment to prove the fallacy of the argument that oft-times the tissues of

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<sup>31</sup> Fox, N., and Harned, J. W. Treatment of Asthmatic Patients in Otolaryngologic Practice, Arch. Otolaryng. 25: 393 (April) 1937.



allergic persons are sterile, a statement frequently seen in the literature. Small pieces of tissue collected from the antrums of 25 allergic patients were obtained aseptically at operation. Only those antral tissues were taken which had proved sterile on washing. One portion was cultured on artificial mediums, then fixed and stained by the Giemsa method, while another portion was implanted in the peritoneal cavity of a guinea pig under aseptic precautions. After forty-eight hours the implanted tissue was removed, cultured and then fixed, sectioned and stained by Giemsa's method. Of the 25 specimens implanted, all revealed large numbers of bacteria, the coccal organisms predominating. Of the 25 duplicate tissues not implanted, only 8 were shown to be infected with organisms from artificial mediums. The organisms identified were alpha, beta and gamma streptococci, *Staphylococcus aureus*, *Staphylococcus albus*, Friedlander's bacilli and diphtheroids. In terms of virulence, it seems quite likely that the power of invasion of the ordinary respiratory organisms is influenced by specific environmental factors, as was demonstrated by the excessive growth seen in the buried tissues. However, there is no evidence that any known factor promotes easier entry of the respiratory tissues. It appears rather that the respiratory tissues of certain persons who have other allergies show a particular sensitiveness to the virus protein, which results in a combination of this antigen with sessile receptors in the cells, with the production of histamine, resulting in increased permeability and, of course, optimum conditions for the overgrowth of secondary invaders. Troescher-Elam, Ancona and Kerr<sup>32</sup> have recently reported a concentration of a histamine-like material in nasal secretion during colds.

#### SUMMARY

Although it is popularly believed that exposure to cold, humidity, fatigue and debility are associated with lowered resistance to the common cold, confirmatory laboratory data are still lacking. However, these same factors are known to influence severely the allergic state of a patient.

The great frequency of other allergies in the cold-susceptible person or in members of his family suggests a specific allergy to the virus or its proteins.

In searching for other allergies in the cold-susceptible patient, one must remember that the majority of such patients present the borderline or subclinical rather than the frank type of allergy.

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32 Troescher-Elam, E., Ancona, G., and Kerr, W. J. Histamine-Like Substance Present in Nasal Secretions of Common Cold and Allergic Rhinitis, *Am J Physiol* **144** 711 1945.

# CONGENITAL CHOANAL ATRESIA

## A New Transpalatine Technic

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A RECENT review of the surgical technics employed to treat congenital choanal atresia reveals that the maintenance of the normal function of the nasal mucous membrane is frequently disregarded in attempted corrective procedures. The surgical approaches appear to be designed primarily to remove bony obstruction and to maintain an opening. To accomplish these results many and varied surgical procedures have been reported. A new technic having the preservation of nasal function as its chief objective is suggested.

Among the earliest workers to report successful alleviation of the bony obstruction was Emmert<sup>1</sup>. In 1851 he removed the occluding bone with a curved trocar. This method of treatment was soon followed by many others. Electrocautery, chemical cautery, drilling through the nostril, use of mallet and chisel and curettage of various sorts were all tried, with varying degrees of success. The formation of scar tissue usually resulted in late closure of the opening and necessitated repeated operation. Most of these intranasal technics were unsuccessful.

In the early part of the twentieth century a new step was added. After the occluding bone was removed, the posterior part of the vomer was rongeuired away, thus a large cavity was formed anterior to and confluent with the nasopharynx. In spite of this added step, many openings so created eventually closed. In an effort to prevent these closures, electrocoagulation, skin grafts and foreign bodies were employed subsequent to the initial surgical intervention. The results were unpredictable and usually not entirely satisfactory.

In a further effort to improve the end results, Kazanjian<sup>2</sup> developed the technic of first performing a submucous resection, after which the

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<sup>1</sup> Emmert, cited by Boyd, H M E. Congenital Atresia of the Posterior Nares. Descriptions of Technics Used in Meeting the Operative Difficulties and Report of a Case, *Arch Otolaryng* **41** 261 (April) 1945

<sup>2</sup> Kazanjian, V H. Treatment of Congenital Atresia of the Choanae, *Ann Otol, Rhin & Laryng* **51** 704, 1942

vomer and the bony obstruction were removed. In his procedure the columella was divided close to the floor of the nose, and the dissection was then carried upward and backward so as to free the septal cartilage, intact. The bony septum, together with its mucous membrane and all the occluding bone, was next removed. The cartilaginous septum was restored to its usual position and sutured into place. The results were somewhat better.

Transpalatine approaches were not overlooked. As early as 1909 Brunk<sup>3</sup> described his use of a longitudinal incision made in the midline of the palate. The results were not good, however, as scar tissue soon filled the nasal opening.

In 1931 Blair<sup>4</sup> described removal of the major portion of the hard palate and the cartilaginous and bony septums. Working through this opening in the bone he was able to find and remove fibrous tissue lying between the nasal floor and the nasopharynx. The mucoperiosteum of the floor of the nose and that of the septum were then sutured together, forming a continuous passage into the nasopharynx. This was a tremendous step forward, in our opinion, for it represented an attempt to institute a normal mucous membrane passage in the nose. Conceivably, this procedure might permit the development of respiratory epithelium with cilia and thus normal functioning of the nose. Previously a fistulous tract lined with scar tissue, skin or scarified mucous membrane had been the ultimate goal of surgical treatment.

Since that time various incisions made through the palate have been tried. Representative of many were the tongue-shaped flap suggested by Steinzeug<sup>5</sup> and the central incision with upper and lower cross cuts used by Schweckendiek<sup>6</sup> and Rebelo Neto<sup>7</sup>. These incisions still caused excessive scarring, which resulted principally from the extensive dissection of the hard palate and the destruction of the nasal mucous membrane. The removal of the palatine bone opposite the occluding area only, reported by Ruddy,<sup>8</sup> was a definite improvement. In our opinion, however, excessive scar tissue results from the removal

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3 Brunk, A. A new Case of Unilateral Osseous Choanal Occlusion. An Operation Through the Palate, *Ztschr f Ohrenh* **59** 221, 1909.

4 Blair, V. P. Congenital Atresia or Obstruction of Air Passages, *Ann Otol, Rhin & Laryng* **40** 1021, 1931.

5 Steinzeug, A. Surgical Technique for Removal of Choanal Coalescences, *Arch f Ohren-, Nasen- u Kehlkopfh* **137** 364, 1933.

6 Schweckendiek, H. Transpalatinal Therapy of Congenital Choanal Atresia, *Ztschr f Hals-, Nasen- u Ohrenh* **42** 367, 1937.

7 Rebelo Neto, J. Transpalatine Route in Therapy of Bilateral Congenital Imperforation of Choanae, with Report of Cases, *Rev brasil de oto-rinolaryng* **10** 431, 1942.

8 Ruddy, L. W. Transpalatine Operation for Congenital Atresia of the Choanae in the Small Child or the Infant, *Arch Otolaryng* **41** 432 (June) 1945.

of the posterior portion of the septum. Another advance was reported by Klaff,<sup>9</sup> who made an incision through the soft palate and opened the closed choanae with rasps under direct vision. The second step of his procedure is difficult to understand, however, because he removed the bony portion between the open nostrils at a later date.

The importance of ciliary action in nasal function, so forcefully demonstrated by Proetz,<sup>10</sup> makes it probable that the nose cannot function properly without it. The fistulous tracts produced by most of these operations are entirely without cilia.

A surgical method employing earlier technics and yet preserving functions of the nasal mucous membrane in keeping with the postulates of Proetz<sup>10</sup> is therefore suggested, whereby the bony obstruction is removed and the normal function of the nasal mucous membrane is maintained. Following is the report of a case of congenital choanal occlusion with a summary of the method used in treating it.

#### REPORT OF A CASE

S. R., an 8 year old white girl, was admitted to the Salt Lake County General Hospital on May 13, 1946 with the complaints of (1) "obstruction of the left nostril since birth" and (2) "almost constant discharge from the left nostril since shortly after birth."

The infant was born spontaneously at term after uneventful labor. In the nursery she appeared normal, took all feedings well and gained weight. Shortly after the infant was discharged from the hospital, the mother noticed a watery fluid escaping from the nose. Believing that the infant had a "cold," she paid little attention to the difficulty. After a few weeks, however, the fluid was still observed, coming principally from the left side of the nose. The family physician prescribed nose drops. For short periods it was thought that the discharge had subsided somewhat, and the nose drops were used intermittently. It became apparent that the discharge was continuing in spite of the therapy, and other kinds of nose drops were tried. These treatments went on until the child was 3 years of age, then the physician decided to operate surgically "to permit drainage from the sinuses." This operation failed to alleviate the condition, and after a few months it was decided to remove the child's tonsils and adenoids. After their removal the parents believed the condition was improved, but it was not long until the discharge was as it had been before the operation.

At the age of 5 years the child began to experience occasional mild frontal headaches. These headaches were always accompanied by some dizziness and were relieved promptly by acetylsalicylic acid and short periods of rest in bed. At about this same time she experienced her first epistaxis. The bleeding usually came from the left nostril and was said to occur without trauma or apparent cause. However, the child was frequently seen placing a finger in her nostril, wiping away nasal discharge and rubbing the outside of the nose.

<sup>9</sup> Klaff, D. D. Bilateral Congenital Atresia of the Choanae, *Arch Otolaryng* 41:298 (April) 1945.

<sup>10</sup> Proetz, A. *Essays on the Applied Physiology of the Nose*, St. Louis, Annals Publishing Company, 1941.

The child was unable to enjoy, and refused to perform, any actions which necessitated flexing the head on the neck. Soon after the head was placed in this position, fluid could be seen dripping freely from the left nostril. She did not want to play the piano, draw or color pictures or participate in activities which demanded that she bend the head forward for any length of time. In spite of this she remained relatively unaffected by the limitations imposed on her until she entered school. At that time she hesitated to participate in various activities because the nasal discharge drew comments from her schoolmates. Because of these remarks, she began to withdraw from groups and group activities. She began to be "nervous," and her appetite flagged. Nasal twitching and facial grimacing became much more noticeable, and occasional nocturnal enuresis occurred. Because of these developments and the fact that the nasal discharge was still present, the child was referred to a local pediatrician. An obstruction of the left side of the nose was discovered, and the child was referred to this hospital for treatment.

Other illnesses in the past had included "infrequent colds," "hay fever" in the month of May only, measles and chickenpox. The child had been immunized against diphtheria, pertussis and smallpox.

The family history was noncontributory.

At the time of admission the rectal temperature was 100.4 F, the pulse rate was 100 per minute and the respiratory rate was 20 per minute. The patient's height was 46 inches (117 cm), her weight 56 pounds (25 Kg), and the Wetzel grid<sup>11</sup> showed the patient to be A<sub>3</sub>, 65 units, 67 per cent. The systolic blood pressure was 106 and the diastolic blood pressure 74. The child appeared neither acutely nor chronically ill or distressed. She was cooperative and pleasant and appeared fairly well nourished. During the interview and the physical examination she was seen occasionally to wipe away a thin, watery nasal fluid and to sniff and rub her nose more frequently. Except for a grade 1 soft blowing systolic murmur, heard best at the left sternal border, the positive findings of the physical examination were limited to the left side of the nose. The external contour of the nose was asymmetric in that the left naris was broader and wider than the right. The left ala nasi was thicker than the right, and the left side of the nose had a somewhat more flattened appearance. There was evidence of recent trauma (probably from finger nails) in the left vestibular area of the nose. The mucous membrane was pale pink and glistening. In the floor of the nose there was a pool of odorless gray mucoid discharge. The septum was straight and imperforate. The inferior turbinate appeared to enlarge posteriorly and was very firm to the touch. The right side of the nose appeared normal in all respects. When the child was asked to bend her head forward, fluid began to drip slowly from the left nostril. After the mouth and the right side of the nose were closed, the child was unable to force air either in or out through the other nostril. A probe placed in the left side of the nose met a definite, impassable obstruction at a depth of 3.0 cm. Iodized poppyseed oil 40 per cent was instilled into the left side of the nose, and roentgenograms were taken. Following is the interpretation of the films as reported by Dr. Henry H. Lerner, of the department of roentgenology of the University of Utah.

"Films taken after iodized oil had been instilled into the left naris showed complete obstruction of the posterior nasal airway. The iodized oil was distributed over the turbinates without any of it entering the pharynx."

11 Wetzel, N. C. Assessing the Physical Condition of Children, *J. Pediat.* **22**, 82, 208 and 329, 1943.

Repeated studies of the blood and the urine gave normal results. The Mantoux and Kahn tests were negative. Cultures of material taken from the nose revealed a mixed growth of streptococci, pneumococci and staphylococci.

On the fourth hospital day the patient was taken to the operating room. With the patient prone, intubation was carried out, and the head was lowered about 12 inches (30 cm). The mouth was kept open with a Davis mouth gag. An incision of the hard palate was made parallel to, and  $\frac{1}{4}$  inch (6.5 mm) to the left of, the midline, it began at the border of the hard palate and extended  $\frac{1}{2}$  inch (12.5 mm) anteriorly. The incision was carried through mucous membrane, muscles and periosteum. The periosteum was elevated laterally and retracted. A square of bone approximately the size of the obstruction was removed. We then took out

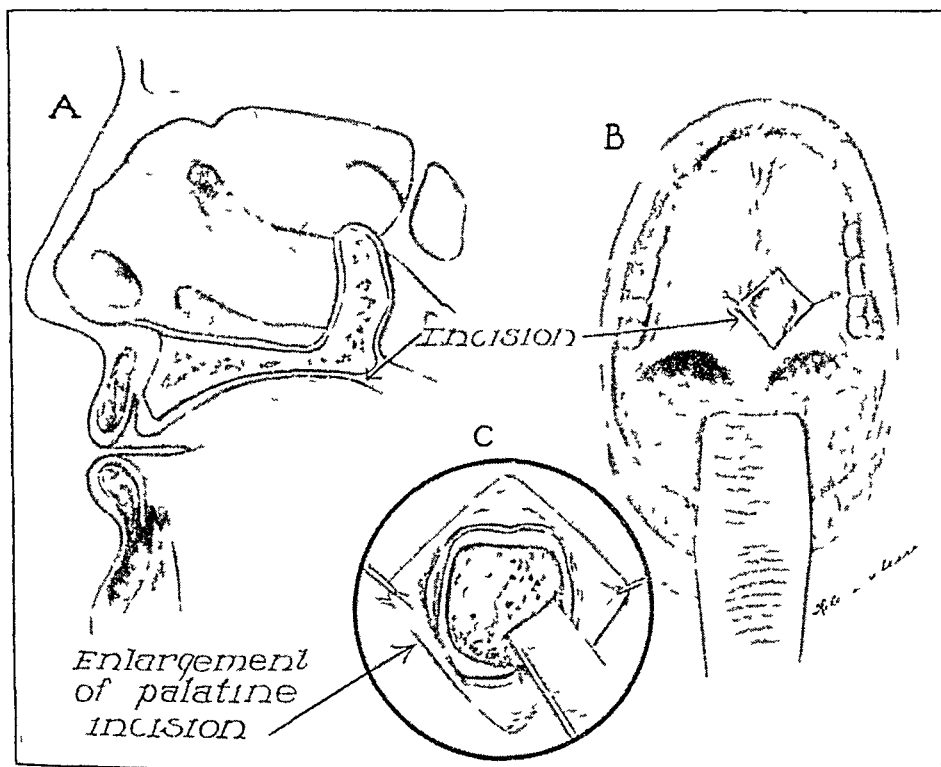


Fig 1—Steps by which the bony obstruction of the left nasal passage was removed

as much of the obstructing bone as could be reached by gouge, chisel and punches, using a submucous resection technic from below. During this removal care was observed to attempt to leave intact the mucous membrane covering the bony obstruction. Except for a few minor tears this goal was accomplished. After the removal of the bone we had an empty shell of mucosa having a somewhat pyramidal shape, with the base overlying the hole in the hard palate. Through the nostril a single vertical incision was made through both walls of this membrane. Thus the anterior and posterior wall of this mound each became separated into two flaps which when loosened at the base simulated swing doors. On each side the anterior flap was moved laterally and posteriorly and the posterior flap was moved laterally and anteriorly. This formed a continuous lining along the sides of the nose, and the redundant tissue remained as a partial carpet for the floor of the nose. This lining was packed lightly in place with petrolatum gauze, and a

section of no 20 catheter was placed inside the petrolatum gauze. A counter-incision made medial to the palatine artery and parallel to the operative incision permitted closure of the operative site without any tension on the suture. The patient was returned to the ward in good condition.

One hour after the completion of the operation the child was talking with her mother and had no complaints except that she was nauseated and her throat hurt. Fluids were administered intravenously for some ten hours, and then oral administration of fluids was started. After the operation the temperature rose to 101.2, and 20,000 units of penicillin was given every three hours. On the second post-operative day the temperature and the pulse rate dropped to normal and remained normal until the patient was discharged from the hospital. She began to take fluids orally freely on the second postoperative day. She was permitted to eat a soft diet.

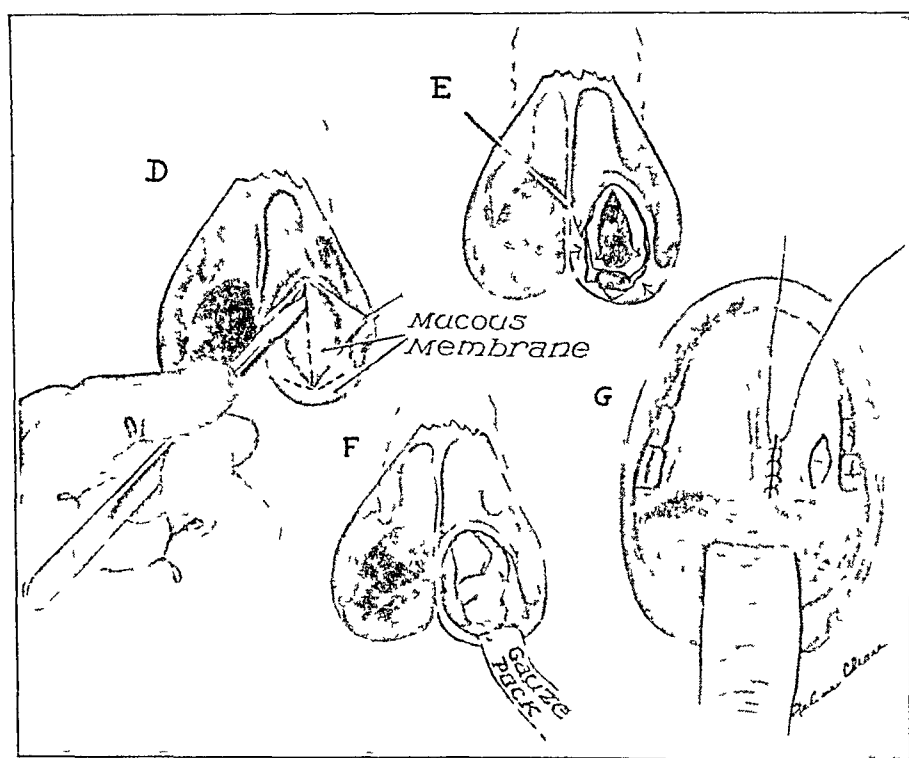


Fig 2—Steps by which the conserved ciliated mucous membrane was used to line the new nasal passage

for twenty-four hours and a regular hospital diet thereafter. The nasal opening healed rapidly, and the child was able to breathe easily through the left side of the nose. She was discharged from the hospital eight days after admission and five days after operation. At the time of discharge a small amount of sero-sanguineous fluid was escaping at intervals from the left naris.

Two weeks later when the patient returned for a checkup accompanied, by her family, it was observed that the entire family had stuffy or running noses. The patient's nasal mucosa was greatly swollen, and a large crust was present over the incision. The crust was removed from the nose, and the patient instructed to return in two weeks. One month after the surgical procedure the child was able to breathe through a large opening in the left side of the nose. There was no discharge.

Four months after operation the patient again returned for examination. She was breathing comfortably through both nostrils. There was no discharge in her nose. Her weight had increased 8 pounds (3.6 Kg) since the operation, and she had returned to school, where she was happy and doing well. She was no longer nervous, and there had been no further enuresis. The opening in the left side of the nose was about the size of a pencil. The patient was seen again thirteen months after operation. During this period she had had few "colds," and her nose had been comfortable at all times. She was able to breathe easily through both sides of the nose. An applicator passed easily into the nasopharynx through the opening, which had not decreased in size.

Although the period since surgical intervention has been over two and a half years, the results seem promising in that little scar tissue has formed. Ciliary action probably is present, for even with a "cold" occurring several weeks after the operation the nasal drip did not reappear.

The results observed in this case lend support to the theory that the successful treating of congenital choanal atresia depends less on the size of the opening made than on a continuous lining of functioning ciliary mucosa. It is possible that further studies may reveal new surgical approaches that will simplify the correction of this deformity.

Among the striking features of the case were the psychologic influence of this relatively minor physical defect on the child and the prompt improvement which followed the correction of the abnormality.

#### SUMMARY

A review of the literature shows clearly that surgical repair of congenital choanal atresia has in the past rarely been successful. Failure has almost always been due to secondary scar formation which closes the opening, despite attempts to produce a permanent fistula by means of skin grafts, prostheses or repeated cauterizations. Even in those instances in which a permanent fistula has been made there has usually not been a return to normal nasal function, owing to the fact that no ciliated epithelium lined the new opening.

A new approach to this problem is described which permits the obstructing bone to be removed by a transpalatine technic and a new nasal passage to be formed which is lined with flaps of ciliated mucous membrane.

One case is reported in which this technic was used. The patient has experienced entire relief of her nasal complaints since the operation thirty-one months ago. The emotional and social readjustment following the alleviation of this minor defect was striking.

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## WHICH IS THE PREFERABLE METHOD OF PERFORMING THE CALORIC TEST?

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THE CALORIC test is one of the most used clinical methods of investigating the vestibular organ. The utility is evident, as it enables one to get information on the localization of a deviation not only in one labyrinth but even, as has been made probable of late, in the central nervous system. However, to be able to compare the results of different workers, the execution of the test has to be identical, and thus it seldom is. Barany,<sup>1</sup> though not the first to observe the reaction of the vestibular organ on caloric stimulation, an honor which belongs to Brown-Sequard<sup>2</sup> and Breuer,<sup>3</sup> was the first to see the clinical importance of this method and also the first to give a theory as to the origin of the reaction and a description of the phenomena which occur when an ear is syringed with cold or warm water—all this in such a way that hardly any essentially new data are registered in later work on this subject. But after him many observers, using as many different technics, studied the caloric sensitivity of the semicircular canal (Brunings<sup>4</sup>, Kobrak<sup>5</sup>, Fischer<sup>6</sup>, Hallpike<sup>7</sup>). The importance of the

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1 Barany, R. Untersuchungen über den vom Vestibularapparat des Ohres reflektorisch ausgelosten rhythmischen Nystagmus und seine Begleiterscheinungen, *Monatsschr. f. Ohrenh.* **40** 193, 1906.

2 Brown-Sequard, C. Course of Lectures on the Physiology and Pathology of the Central Nervous System, Philadelphia, Collins, 1860, p. 187.

3 Breuer, J. Neue Versuche an den Ohrenbogengängen, *Arch. f. d. ges. Physiol.* **44** 135, 1889.

4 Brunings, H. Beiträge zur Theorie, Methodik und Klinik der kalorimetrischen Funktionsprüfung des Bogengangsapparates, *Ztschr. f. Ohrenh.* **63** 20, 1911.

5 Kobrak, F. Beiträge zum experimentellen Nystagmus, *Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres* **10** 214, 1918, **11** 244, 1919, Zur Frage einer exakten Messbarkeit der Sensibilität des Vestibularapparates, *Arch. f. Ohren, Nasen- u. Kehlkopfh.* **105** 132, 1919-1920.

6 Fischer, M. H. Grundsätze für die Normung der vestibulären Nystagmusprüfung, *Klin. Wchnschr.* **12** 1925, 1933.

7 Hallpike, C. S. The Investigation of Meniere's Disease, *J. Laryng. & Otol.* **43** 349, 1943.

position of the head in the performance of the test (Brunings<sup>4</sup>), the necessity to avoid too intense stimuli (Kobrak<sup>5</sup>) and the desirability of proof of not only the frigorice but also the caloric excitability (de Kleyn<sup>8</sup>) are generally accepted nowadays

Kobiak, however, stressed the importance of employing small quantities of water in executing the test, whereas Hallpike<sup>7</sup> has used a large quantity of water. Most investigators try to limit the fixation of the eyes with strong biconvex glasses, following the method of Bartels or Frenzel, a method rejected by Hallpike

The position of the patient is not the same for every examiner, for instance, according to Brunings,<sup>4</sup> a fixed optimum position is preferred by many authors, but Fischer<sup>6</sup> syringes the ear in the zero position and turns the head backward one minute later

In a great number of experiments on normal subjects I have tried to solve the question whether there is a method which actually surpasses others. In order to obtain an answer to this question I have tried variations in some minor parts of the technic of the caloric test

The first question arising is Which phenomenon caused by the thermic stimulation of the labyrinth lends itself best to being measured? The labyrinth, being a sense organ, produces sensations and reflexes in the same way as any other sense organ. While avoiding a thorough study of the theories concerning the origin of the phenomena produced by thermic stimulation, one may accept a stimulation of the vestibular nerve or of parts of it by the way of a stimulation of the peripheral organ without being too imprudent

This stimulation causes a sensation of turning and (or) of change of the position of the body in space and an alteration of the tonus of groups of muscles throughout the body. The latter may be observed in the limbs—deviation in walking with eyes closed, deviation in the Romberg test *de fil à plomb* and deviation in the pointing tests according to Barany and Quix and in the eyes (nystagmus). The nystagmus, however, is a more complex phenomenon consisting of a quick and a slow phase. The latter is the same as the variation of tonus in the entire musculature, while the quick phase is a specific property of the movements of the eyes, probably originating in the central nervous system (in general anesthesia the quick component of the nystagmus disappears, the slow component remains) (Quix<sup>9</sup>, Wodak<sup>10</sup>)

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<sup>8</sup> de Kleyn, A. Detournements des differentes formes de nystagmus dans le systeme nerveux central, *Versl v d Nederl Akad v Wetensch* **44** 268, 378 and 540, 1941

<sup>9</sup> Quix, F. H. Les methodes d'examen de l'organe vestibulaire, Paris, Vigot Freres, 1929

<sup>10</sup> Wodak, E. Zur Physio-Pathologie des Vestibularapparates, *Pract oto-rhino-laryng* **9** 30, 1947

In the University Clinic for Diseases of the Ear, Nose and Throat my colleagues and I have learned to appreciate the usefulness of vestibular sensation in obtaining quantitative data on the function of the vestibular organ by performing the turning test with small regulable stimuli (in the same way as the sense of hearing is measured in audiometry) (van Egmond, Groen and Jongkees<sup>11</sup>) In the case of the caloric test, however, the sensation failed to give us valuable information Many patients, even those who were used to self observation, had no turning sensation whatsoever, others needed strong stimuli to get a sensation In most cases the sensation appeared long after the nystagmus and disappeared long before the nystagmus ceased

This is in clear contradiction to the experiments of Fischer and Wodak,<sup>12</sup> which indicated that in the caloric test sensation is a much more sensitive basis for examination than nystagmus They experimented only with themselves as test subjects, and their great training in self observation may explain these results, but for an investigation of clinical technics it is unserviceable

The influence of the labyrinth on the muscle tone of the body, measurable in the walking test or the pointing test, is not suitable for a quantitative analysis Therefore we are obliged, as has been done since the beginning of the clinical practice of the caloric test, to use the nystagmus as an indicator of the activity of the vestibular organ As we always use the more perceptible quick phase, the activity of the vestibular organ is observed by the assistance of a reflex which is certainly of nonvestibular origin

However, one may consider the nystagmus from different angles Its properties suitable for measurement are strength, frequency, time of latency and duration It is not easy to measure the strength of the nystagmus, which is not the same as the proportion of duration and frequency, and the many methods described in which such measurements have been made by registration of the nystagmus do not lend themselves to common clinical use (Wotzilka,<sup>13</sup> Ohm,<sup>14</sup> Kuilman<sup>15</sup> and Perlman and Case<sup>16</sup>)

11 van Egmond, A A J, Groen, J J, and Jongkees, L B W The Turning Test with Small Regulable Stimuli—I, *J Laryng & Otol* **62** 63, 1948

12 Fischer, M H, and Wodak, E Experimentelle Untersuchungen über Vestibularisreaktionen, *Ztschr f Hals-, Nasen- u Ohrenh* **3** 198, 1922

13 Wotzilka, G Ein neuer, klinisch verwendbarer Nystagmograph, *Ztschr f Hals-, Nasen- Ohrenh* **8** 93, 1924

14 Ohm J Untersuchung des Augenzittern, in Alexander, G, and Marburg, O *Handbuch der Neurologie des Ohres*, Berlin, Urban & Schwarzenberg, 1924, vol 1, p 1098

15 Kuilman, J Nystagmographie während der Drehung, *Ztschr f Hals-, Nasen- u Ohrenh* **35** 85, 1933

16 Perlman, H B, and Case, T J Nystagmus Some Observations Based on an Electrical Method for Recording Eye-Movements, *Laryngoscope* **49** 217, 1939

In order that the results of various scientific workers may be compared, it is of paramount importance to give numbers and methods which can be easily imitated. Only in this way may so-called objective results be obtained. The strength of the nystagmus cannot yet be given in a number and is therefore not suitable for our purposes.

The frequency of the nystagmus is easily given in a number, but the result is not the same when the experiment is repeated under the same outer circumstances. The result is not reproducible, varying greatly in the same patient, as already been shown by Fischer<sup>17</sup> and Woletz<sup>18</sup>. I have the impression that it is possible in many instances to influence the frequency of the nystagmus by concentrating the patient's attention as well as by rubbing the cheek with alcohol or by other means (Hennebert<sup>19</sup>, Grahe<sup>20</sup>).

The third possible indicator of the caloric stimulation of the labyrinth, i.e., the time needed for the stimulus to cause the first quick phase of nystagmus, is judged differently. According to Cawthorne, Fitzgerald and Hallpike<sup>21</sup> and Barbey<sup>22</sup> it is not of much value, since it is strongly influenced by the bony structure of the petrous bone. On the other hand, Brunner<sup>23</sup> expressed the opinion that the time of latency is important and may indicate an alteration in the excitability of one labyrinth (Brunings<sup>24</sup>).

Clinically the most usual means of judging the results of the caloric test is the duration of the nystagmus. In this series I have tried to find the most reasonable way to perform the caloric test with the help of the nystagmus, especially its frequency, time of latency and, most important, duration.

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17 Fischer, M. H. Die Regulationsfunktionen des menschlichen Labyrinthes und die Zusammenhänge mit verwandten Funktionen, *Ergebn d. Physiol.* **27** 209, 1928.

18 Woletz, F. Studie zum vestibulären Erregungsablauf mittels des kalorischen Nystagmus, *Ztschr. f. Hals-, Nasen- u. Ohrenh.* **30** 524, 1932.

19 Hennebert, P. Inhibition périphérique des réactions vestibulaires, *Bull. Soc. belge d'oto, rhinol., laryng.*, 1946, p. 86.

20 Grahe, K. Zur Wirkungsweise des kalorischen Schwachreizes, *Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres* **19** 101, 1923.

21 Fitzgerald, G., and Hallpike, C. S. Observations on the Directional Preponderance of Caloric Nystagmus Resulting from Unilateral Labyrinthectomy, *Brain* **65** 115, 1942.

22 Barbey, E. Les encéphalopathies traumatiques au point de vue neuro-otologique, *Arch. suisses de neurol. et psychiat.* **50** 345, 1943.

23 Brunner, H., in Alexander, G., and Marburg, O. *Handbuch der Neurologie des Ohres*, Berlin, Urban & Schwarzenberg, 1924, vol. 1, p. 239.

24 Brünings. Ueber quantitative Funktionsprüfung des Vestibularapparates. *Verhandl. d. deutsch. otol. Gesellsch.*, 1910, p. 180.

There is one point left to be considered. Is it useful to inhibit the fixation of the eyes with strong biconvex glasses as advocated by Bartels and Frenzel? As Hallpike<sup>7</sup> pointed out, those glasses do not make it easier to establish the end of the nystagmus. But, on the other hand, their use ascertains the exclusion of the purely nonvestibular factor introduced by fixation of the eyes.

Moreover, Frenzel's glasses enable one to see even the smallest movements of the eyeball by their magnification and good illumination. For these reasons I used the biconvex glasses of Frenzel in all experiments mentioned in the following section.

#### EXPERIMENTAL SUBJECTS AND PRELIMINARY OBSERVATIONS

All the experiments were performed on normal subjects, students at the University Clinic, who never had any complaints concerning their ears, hearing or vestibular functions. The normal aspect of their ear drums was controlled before the performance of the tests.

Because of the difficulty of ascertaining the end of the nystagmus, a genuine pure issue of such experiments is not easily obtained, hence some precautions are desirable. To exclude any influence of the knowledge of other values already obtained in a subject, the stopwatch with which the duration of the nystagmus or of any other time is measured should be handled by a co-worker, who stops it at the indication of the observer. In order to measure the same thing every time, the observer has to know exactly what he wants to measure. In these experiments the nystagmus was considered to be present as long as the slow movement could be perceived clearly. The time of latency and the duration were measured from the end of the syringing.

The time of latency, always measured till the first quick movement, is in reality shorter, as a slow phase always precedes the quick one.

Nevertheless it is extremely difficult to see the real beginning of the nystagmus (slow phase). Since it takes much practice even for a person who has carried out the clinical caloric test for many years to be able to get results sufficiently reproducible that conclusions of general value may be drawn from them, the value of the time of latency can be based only on the beginning of the quick movement of the nystagmus, for it is considered impossible to measure it for the slow phase with enough certainty. The origin of the first quick movement, however, is influenced by so many extr vestibular phenomena that its value as an indicator of vestibular activity should be strongly doubted.

For the practical use of the caloric test it is of the utmost importance to know how much time has to be allowed to pass before one applies another douche of the ear without danger of the results being influenced by the preceding test. Many investigators allow a long time to pass before they begin another syringing (about thirty minutes). To accomplish a thorough caloric test, with both ears syringed with cold and hot water, a very long time is needed (Brunner,<sup>23</sup> Hallpike,<sup>7</sup> Woletz<sup>18</sup>). On the other hand, the investigators who use the method of Kobrak with small quantities of water of a temperature not differing much from that of the body perform their tests, for

the most part, with only a small interval (van Denise<sup>26</sup>) According to Lorente de No,<sup>27</sup> the caloric nystagmus has the same duration as the stimulus, which means that the effect of the syringing is past as soon as the thermic effect in the skull is past

While using water of a temperature not differing more than 10 degrees from that of the body we found that an interval between two tests of five to six minutes is long enough to get pure results The duration of the nystagmus after syringing every six minutes is as constant as when we wait a longer time A variation of 10 per cent is found in both instances

The frequency varies so much that it cannot possibly be taken as a quantitative indication of the activity of the vestibular organ Because the variation of the duration of the nystagmus following caloric stimulation varies normally 5 to 10 per cent, I have omitted any appearance of greater accuracy by approximating every value found in these tests to —5 or —0 seconds

Figure 1 shows the result of one series out of many similar ones The duration of the nystagmus after syringing with 50 cc of water of a temperature of 30 C with an interval of six minutes between douches is given, then the duration with an interval of twenty-four hours The same is done for another

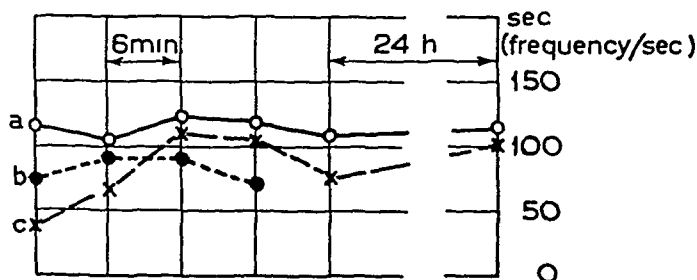


Fig 1—Line *a* represents the duration of nystagmus after an ear has been irrigated with 50 cc of water of a temperature of 30 C at intervals of six minutes Line *b* gives the duration for another ear syringed with 5 cc of water of a temperature of 30 C every six minutes Note the larger variation The frequency of the nystagmus is shown by line *c* Note the absence of any regularity

ear syringed with 5 cc The frequency after each test in the first case is also demonstrated This figure indicates some observations which I made repeatedly An interval of six minutes—i e, the time one needs to refill the syringe with water well adjusted to the right temperature after having read the reaction of the previous test and so to prepare the new one—is absolutely sufficient if one does not give too big a stimulus (see later comment) The results of a test performed with very small quantities of water are less constant than those of a test with larger quantities (50 cc or more) The frequency of the nystagmus is by no means constant, not with small and not with longer intervals If one allows some days to pass between two irrigations of the ears, one finds the same variations as with a pause of some minutes

<sup>25</sup> Footnote has been deleted

<sup>26</sup> van Denise, J B Het Meniere syndroom, Thesis, Amsterdam, 1946

<sup>27</sup> Lorente de No, R Einiges zur Labyrinthphysiologie, Acta-oto-laryng  
11 301, 1927

## EXPERIMENTS ON THE POSITION CHAIR

With the data given in the foregoing section we tried to find the best position for testing the caloric excitability, using the position chair of QUIX<sup>28</sup> According to Brunings,<sup>24</sup> the stimulus—i e, the temperature and the quantity of water necessary to cause nystagmus—is different with different positions In my experiments I could neither corroborate this statement nor find any great influence of the position of the body over a large range

With the subject lying straight on a stretcher, which may be placed in any possible position, it was found that only when the body was placed in such a manner that the horizontal canal was almost vertical did large variations occur If the caloric test is performed with a certain quantity of water of a certain temperature, the duration of the nystagmus is almost the same except for the normal range of variation of 10 per cent, regardless of the turning of the body from an almost vertical position (head above) to about 150 degrees backward

The same is observed if one passes the indifferent zone With the subject turned forward from about 60 to about 180 degrees, the duration of the nystagmus following a definite stimulus is the same We got the impression that the strength of the nystagmus was greatest in the horizontal position and decreased with the angle made by the body with the horizontal plane It may be emphasized that the measurement of the nystagmus in the position in which the head (the body) is inclined forward is much more difficult than in the normal position, not only because the observer is obliged either to use a mirror or to take an inconvenient position to have a good look at the eyes and their movements in the subject, but also because the subject with his head bent forward is uneasy, especially if he is almost in the head down position

This uneasiness has a great influence on the voluntary movements of the eyes This is the reason why we did not trust the numbers in positions of the subject in which the head was down To keep a person in that position long enough to measure the duration of the nystagmus accurately is so extremely disagreeable that I found myself able to accomplish this test with only a few subjects

Figure 2 shows the results of a number of caloric tests made with 50 cc of water of a temperature of 30 C while the subject was on the position chair The values given indicate the duration and the frequency of the nystagmus at such a position that the head points to the value in question, the body being turned on a binaural axis through the center

In the same experiments we were able to corroborate entirely the issue of the investigations of Behrman<sup>29</sup> The results of these experi-

28 QUIX, F H Nieuwe foestellen voor het klinisch onderzoek der functie van het vestibulaire organ, *Nederl tijdschr v geneesk* 71 194, 1927

29 Behrman, W Ueber Indifferenzlagen und Nystagmusgebiete Versuche mit Kreisbewegung des Kopfes in der Sagittalebene nach einseitiger kalorischer Reizung, *Acta-oto-laryng*, 1940, supp 40, p 1, Versuche mit horizontal liegenden nach einseitiger kalorischer Reizung um ihre Langsachse rotierten Personen, *ibid* 30 298, 1942

ments duplicate those found earlier by de Kleyn and Storm van Leeuwen,<sup>30</sup> but they did not stress the fact that the angle of the upper region of the nystagmus is larger than that of the lower one

The first is of the order of 200 degrees, the second, of the order of 140 degrees. The remaining angle is occupied by the zones of indifference

We found almost exactly the same values in our experiments in contradiction to Veits,<sup>31</sup> who claimed that the zones of indifference diverge exactly 180 degrees

Always, or nearly always, the nystagmus is of shorter duration in the reversed than in the normal position

Still one other symptom is of importance for the performance of the caloric test—i.e., the influence of movements of the subject during the test. When a subject is tested in the reversed position and the duration is taken, we put him back in the normal horizontal position (lying on the back). In every instance we found that the nystagmus

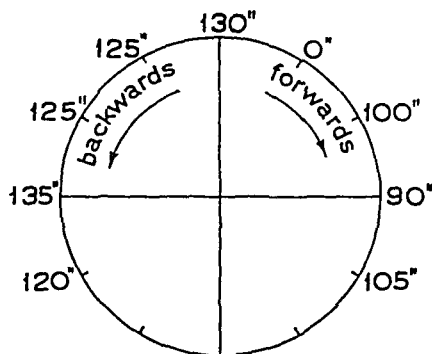


Fig 2—The duration of the caloric nystagmus of a subject on the position chair, measured in different positions on a binaural axis. The numbers indicate the duration in seconds. Each number belongs to the angle (next to which it is placed) indicating the inclination of the body

belonging to the stimulus in that position occurred, but was of much longer duration. Some instances may illustrate this

1. A caloric test with 50 cc of water of 30 C in the right ear causes nystagmus to the left of a duration of 180 seconds in a position 60 degrees backward and nystagmus to the right of 120 seconds if the body is in the reversed position, i.e., 120 degrees forward. If after the end of the last nystagmus the subject is turned back very slowly from the reversed position to the original backward position in such a way that only one or two vertical nystagmus beats are elicited, immediately nystagmus to the left starts again and lasts for 270 seconds. This nystagmus is almost purely horizontal with only a small rotatory component, not larger than a test performed entirely in the normal position would have

<sup>30</sup> de Kleyn, A., and Storm von Leeuwen, W., Ueber vestibulare Augenreflexe III, Arch f Ophth **107** 109, 1921

<sup>31</sup> Veits, C. Zur anatomischen Charakteristik der absoluten kalorischen Indifferenzlage, Arch f Ohren-, Nasen- u Kehlkopfh **118** 303, 1928



shown 2 The same test in another subject performed with water of 44 C gave a duration of the nystagmus to the right of 90 seconds in the normal 60 degree backward position and a duration of nystagmus to the left of 90 seconds, likewise, in the reversed 120 degrees forward position After the subject was brought back to the normal position the nystagmus to the right returned and continued for more than 180 seconds, i e, a total duration of about 300 seconds

However, in repeating such an experiment, even when we tried to make every part of it identical as compared with the previous one, we found other values not for the primary reaction but for the duration of the nystagmus after the movement It may be superfluous to state that we never found horizontal nystagmus after turning the subject on a binaural axis if no thermic stimulus was applied

This result causes us to doubt the quantitative value of any caloric test performed on a patient who is moved during the test as indicated, for instance, by Brunings<sup>4</sup> and Fischer<sup>6</sup> The rotatory component of the nystagmus may be of great importance neurologically, as claimed by Aubry,<sup>32</sup> but in that case the measurement of this rotatory component in the Brunings position optimal to obtain it cannot be combined with a quantitative determination of the duration of the nystagmus in the normal position

Concluding, one may state that for the caloric test the best position of the patient is that of lying horizontally with the head raised on a pillow at an angle of about 30 degrees In this way the patient is as much at ease as possible and the nystagmus is strongest There is no need to obey stricter rules, since over a large range the duration of the nystagmus is identical, and it is fairly easy to keep the patient in the same position during the whole time of a caloric examination made on both ears with hot and cold water

#### INFLUENCE OF THE QUANTITY OF WATER USED IN THE CALORIC TEST

With the subject in the aforementioned position, I have tried to ascertain the quantity of water most suitable for the caloric test A priori one would be inclined to think that the quantity of water should be of great importance to the duration of the nystagmus Nothing appears to be less true If water is used at a temperature not too near body temperature—for instance, 30 and 44 C—the influence is absolutely negligible Figure 3 gives some examples of the duration of the nystagmus in caloric tests with different quantities of water If the temperature differs much from that of the body, the duration of the nystagmus after small quantities of water is usually longer than after large quantities (upper line) This is what Kobrak called the

32 Aubry, M Oto-neurologie Technique et interpretation des examens labyrinthiques, Paris, Masson & Cie, 1944

inhibition of the nystagmus by large quantities of water. We do not share his opinion on the main points of the problem, but we hope to discuss this in a later paper.

The two middle lines of figure 3 indicate the duration of the nystagmus with different quantities of water at the temperatures 30 and 44 C.

It is obvious that the influence of the quantity is of no importance here for the duration. On the other hand, the lower curve is obtained with water of 35 C. Here a large quantity induces a longer nystagmus than a small quantity.

These results, however, do not imply that the quantity of water is of no importance at all. It is difficult to measure the end of the nystagmus if one uses small quantities of water. A subject whose ears are syringed with, let us say, 5 cc of water has many irregularities in the movements of his eyes, especially at the end of the nystagmus. He has voluntary movements of the eyes, or apparently such, which he is unable to dominate, he blinks his eyelids, sometimes even the

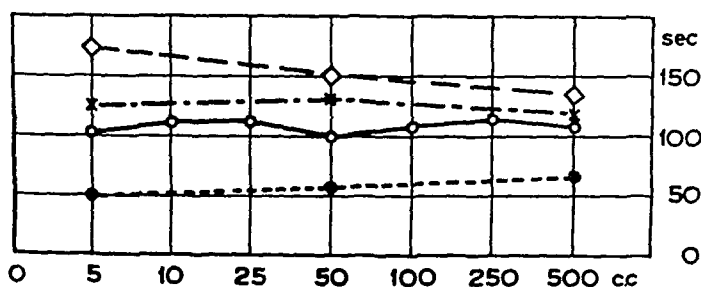


Fig 3—The duration of the nystagmus is set out as a function of the quantity of the water used for the test (abscissa). The upper line indicates the values found for water of a temperature of 18 C. The second line is for water of 30 C, the third, for water of 44 C, and the lowest line, for water of 35 C. The graphs are taken from four different subjects, each series, from one subject.

pupils quickly alter in size, and, finally, the magnitude of the nystagmus is usually very small. These factors make it extremely difficult to get reliable results.

If larger quantities are used, these difficulties do not arise to such an extent. On the other hand, it is impracticable to use large quantities of water, which give good results but require special instruments and arrangements for the tests and are more liable to cause vertigo and sickness in the patients.

A moderate quantity of about 50 cc has many advantages. It does not require special arrangements, a normal ear syringe, according to Alexander, has a capacity of about 50 cc. It is enough to avoid the trouble of the very small quantities and not so much as to cause great trouble to the patient.

Concluding, I advocate that about 50 cc of water be used in the performance of the caloric test, on account of its practical advantages

#### INFLUENCE OF THE TEMPERATURE OF THE WATER USED IN THE CALORIC TEST

The influence of the temperature of the water is much greater than that of the quantity but not as great as one might be inclined to think. As long as the temperature differs little from that of the body an increase of this difference causes an important increase of the duration of the nystagmus, but as soon as the difference is of the order of about

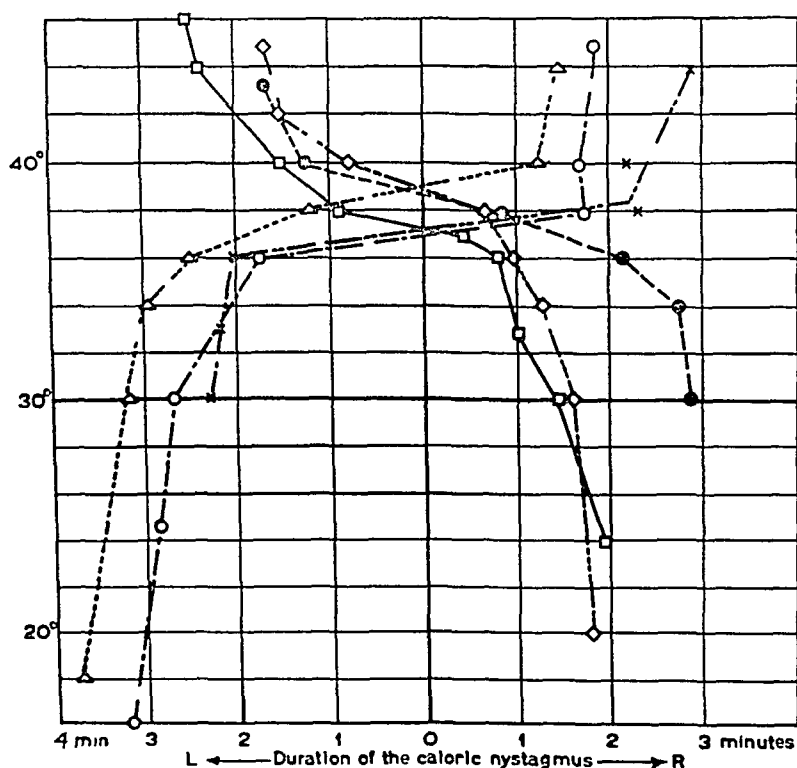


Fig 4—The duration of nystagmus following syringing of the ear with water of different temperatures is put down as a function of the temperature of the water used for the test. On the right side nystagmus to the right is recorded and on the left side nystagmus to the left. The subjects were in the horizontal position. The quantity of water used was 50 cc.

5 degrees a further increase is accompanied by only a small increase in the duration of the nystagmus, so that the difference between the reactions is often less after syringing with water of 30 and of 18 C than that after syringing with water of 35 and 32 C. The diagram in figure 4 shows these facts.

In most instances the reversion of the nystagmus does not occur at the temperature of the body but at 1 or 2 degrees above it. This is not due to the fact that the temperature of the water decreases during

the test, so that the temperature is lower than the measured one. This was proved by experiments during the caloric test in which the temperature at the ear drum was taken with the help of a thermoelectric point. It also indicated that the direction of the induced nystagmus changes at a temperature which lies mostly above that of the body and may even be as high as 39 or 40 C. This does not quite agree with the classic theory of Barány about the origin of the caloric reaction, but this paper is not the proper place to discuss the problem. The graph in figure 4 takes an asymptomatic course as soon as the difference of the temperature of the water and that of the body is large enough. At 34 and 42 C the beginning of this asymptomatic course is obvious usually and at 30 and 44 C always. That a difference of less than 1 degree may cause a clear reaction is shown also in figure 4 (Plum<sup>33</sup>). Using these temperatures, one is practically sure to examine the patients in the vertical part of the graph. Stimuli of greater intensity (greater difference of temperature) only cause greater trouble in the subject (pain, sickness, vertigo), they do not give a better result. In our clinic we therefore use water of a temperature of 30 and 44 C these being stimuli equidistant from body temperature which give good nystagmus without eliciting troublesome symptoms (Hallpike<sup>7</sup>).

Concluding, I advise that water of 30 to 44 C be used for the caloric test, as these temperatures yield the best results with the least trouble.

#### INFLUENCE OF ADVENTITIOUS MEASURES ON THE CALORIC TEST

Especially in the tests according to Kobrak, with very small quantities of water, it always is advisable to point the jet of water against the upper rear part of the ear drum to get the best results.

I could not find any difference in the duration or in the strength of the nystagmus whether the jet was pointed at different parts of the drum or at the wall of the external auditory canal so long as the water streamed amply along the drum. If the direction of the jet was changed during the test, no difference of the temperature of the drum was observed. This was also the case when small quantities of water were used, within large limits the same temperature, as well as the same reaction, was measured at the drum. Carried into practice this means that one needs only to be careful to direct the syringing water amply through the auditory canal.

As little influence as the quantity of water has on the caloric reaction, just so little is the influence of the rapidity of the irrigation of the ear if only the beginning of the reaction is measured from the same point,

<sup>33</sup> Plum, A. Methode zur quantitative Messung, Beitr z Anat Physiol u Therap d Ohres 18 342, 1920

1 e, the end of the syringing We use a moderate velocity of about three seconds per 5 cc, 1 e, thirty seconds for a normal test of 50 cc

It stands to reason that before performing the caloric tests one ascertains that no piece of cerumen closes the auditory canal However, the influence of a little piece of cotton or even cerumen is not as great as one would be inclined to think, at least when larger quantities of water are used An example may illustrate this

A left ear with an obstructing piece of cerumen gave the following reactions when syringed with 50 cc of water at 30 C

Duration	210 seconds
Time of latency	30 seconds
Frequency	130 beats

After the removal of the cerumen the values were

Duration	210 seconds
Time of latency	15 seconds
Frequency	160 beats

Concluding, one sees that the influence of the speed and the direction of the stream of water is extremely small Also the influence of small pieces of cerumen is negligible

#### BILATERAL TESTS

In order to support the data recorded to this point, we tried to verify them with bilateral tests

The bilateral syringing of both ears at the same time with the same stimulus was indicated by Barány and later used by Fischer,<sup>34</sup> Ruttin,<sup>35</sup> Quix,<sup>36</sup> de Kleijn and Versteegh<sup>37</sup> and others

If the stimulus is exactly the same on both sides, there is, for the most part, no nystagmus of the second degree behind Frenzel's glasses However, if one property of the stimulus is changed, a large difference may be introduced without any effect Not before the quantity of the water applied in one ear is five times as much as the quantity in the other ear does nystagmus of the second degree originate, 10 cc at one side and 50 cc at the other side may be tolerated without any effect if one takes care to end the stimulation at the same moment If one uses

34 Fischer, M H Beitrage zur Physiologie des menschlichen Vestibularapparates V Bilateralmethoden speziell Doppelspulungen, Arch f d ges Physiol **213** 74, 1926 footnote 12

35 Ruttin, E Zur Differenzial-diagnose der Erkrankungen des vestibularen Endapparates, der Vestibularnerven und seiner zentralen Bahnen, Verhandl deutsch otol Gesellsch, 1909, p 169

36 Quix, F H Verschijnselen bij het uitspuiten van beide oren tegelijk, Nederl Tijdschr geneesk **74** 1975, 1930

37 Versteegh, C, and de Kleijn, A Some Remarks upon Present Position of Physiology of Labyrinth, J Laryng & Otol **42** 649, 1927

the same quantity of water on both sides, one may change the temperature at either side by many degrees without any effect

If the temperatures in the vertical part of graph 4 are taken, a difference of temperature of 5 degrees is usually tolerated without any nystagmus, while a difference of 10 degrees generally causes definite nystagmus. Syringing in different directions at the two sides has no influence

### CONCLUSIONS

The best method of performing the caloric test is discussed, and reasons are given why the duration of the nystagmus is the best indicator of the reaction of the labyrinth on caloric stimulation. The time of latency, the frequency and the sensations of the subject are less suitable on account of their unreliability. The influence of the position is examined, the best position for the test is the normal horizontal position with the head lifted up some 30 degrees on a pillow (Brunings). The influence of the quantity of water is extremely small. For purely practical reasons, the use of 50 cc is recommended. This quantity

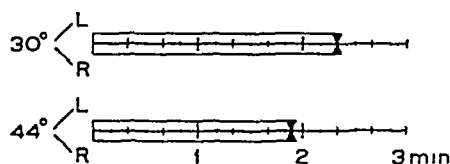


Fig 5—Diagram after Hallpike<sup>7</sup> to register the results of the caloric test. On the diagram the duration and, if necessary, the time of latency may be indicated for both ears at temperatures of 30 and 44 C. Directional preponderance or domination of the reaction of one labyrinth may be read immediately from this diagram. The points given here are the average values of 60 normal subjects.

gives a reaction which is easily measured and does not need special arrangements. A normal ear syringe has this capacity.

The best temperatures to use are about 30 and 44 C, as with these the maximum reactions are obtained with the smallest stimulation, and they do not cause disagreeable symptoms in the patients. There is no need to be especially careful with the direction and the speed of the syringing, as the influence of these factors is small or nonexistent.

Experiments with bilateral syringing confirmed the data mentioned. The diagram given by Hallpike (fig 5) has proved to be extremely useful in the clinical registration of the caloric test.

As set forth in the foregoing pages, the use of cold and warm water is necessary not only to be sure of the presence of any remainder of function of a labyrinth but also to distinguish between directional preponderance and predominance of one labyrinth, a distinction seemingly of great importance for neurologic symptomatology (Hallpike<sup>7</sup>).

## SUMMARY

On account of experiments made in performing the caloric test on normal subjects, the preferable method of performing this test seems to be the following. The subject is placed in the normal horizontal position, the head flexed on a pillow at 30 degrees. Both ears are syringed with 50 cc of water at temperatures of 30 and 44 C.

The interval between the four tests necessary to make a complete caloric examination of vestibular function need not be longer than six minutes. In this way the duration of the whole examination is not longer than about twenty minutes, and it gives every result which may be expected from this kind of examination. The use of the diagram of Hallpike is recommended.

# BENIGN CYSTS OF THE PARANASAL SINUSES

HAROLD F SCHUKNECHT, M D

AND

JOHN R LINDSAY, M D

CHICAGO

**B**ENIGN cysts which are common in and peculiar to the paranasal sinuses are of two general types, those which take origin from the sinus mucosa and those which invade the maxillary sinuses from the teeth. Dermoids and cysts of the facial cleft, which frequently involve the nasal structures, rarely involve the paranasal sinuses proper. While the pathogenesis of some types of cysts found in the sinuses is fairly well understood, the development of others is not adequately explained, nor is the etiology of certain types established.

A simple classification of these cysts is as follows:

- A Cysts arising from the sinus mucosa
  - 1 Nonsecreting cysts
  - 2 Secreting cysts
    - (a) Retention (glandular) cyst
    - (b) Mucocoele
- B Odontogenic cysts
  - 1 Follicular cysts (dentigerous<sup>1</sup>)
  - 2 Radicular (root) cyst

This classification does not include cystic neoplasms, therefore adamantinomas, which may become cystic, are not included.

## CYSTS ARISING FROM THE SINUS MUCOSA

### NONSECRETING CYSTS

The nonsecreting cyst is an accumulation of straw-colored exudate in the subepithelial, loose connective tissue of the maxillary sinuses. Clinical and roentgenologic evidence of its occurrence in other sinuses is lacking.

*Pathologic Factors*—The pathogenesis of this cyst is not clear. Areas of the subepithelial stroma adjacent to such cysts frequently show accumulations of fluid in the tissue spaces. MacGregor<sup>2</sup> pointed out that an increasing accumulation of fluid in the tissue, with the breakdown of interstitial connective tissue septums and the coalescence of these small

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<sup>1</sup> A dentigerous cyst is a follicular cyst which contains a tooth.

<sup>2</sup> MacGregor, G. W. The Formation and Histological Structure of Cysts of the Maxillary Sinus, Arch Otolaryng 8: 505-519 (Nov) 1928.



cystic areas would explain the formation of a larger cyst. These changes in the subepithelium are probably inflammatory. Multiple microscopic collections of fluid are commonly seen with hyperplasia of the sinus mucosa, whether on an allergic or an infectious basis. The typical pathologic picture is shown in figure 1 A. Clinically, these cysts are associated more frequently with infection than with allergy.

The selective occurrence of these cysts in the maxillary sinus is best explained on an anatomic basis. The interstitial fluid probably collects on the floor of the antrum by the force of gravitation, and the thin walls are prevented from rupture by the support of the bony walls of the sinus.

The wall of the cyst varies in thickness but is generally very thin. The lining membrane consists of a few strands of fibrous tissue, and the wall is infiltrated with varying numbers of eosinophils, lymphocytes, plasma cells and neutrophils, the distribution depending on the inflammatory response incited. The sinus mucosa is reflected over the top of the cyst. Eichelberger and Lindsay<sup>3</sup> made a chemical analysis of the fluid of the cyst in 11 cases and found the protein values, specific gravity and pattern of electrolytes to be approximately those of an inflammatory exudate.

*Symptoms*—Symptoms usually are not evident in the case of very small cysts but become evident as the cyst enlarges. A cyst which appears to occupy the lower half or more of the sinus is capable of producing not only local symptoms but also generalized complaints of fatigue, lassitude, headache, dizziness and irritability. This cyst is a relatively common occurrence in clinical practice and was found by Grossman and Waltz<sup>4</sup> in 6 cases in 80 consecutive roentgenograms of the sinuses. In 3 of these cases the patients complained of toothache and were relieved by puncture of the antrum. Straus<sup>5</sup> reported a case in which optic neuritis began to subside two days after removal of a nonsecreting cyst. Lindsay<sup>5a</sup> noted that removal of nonsecreting cysts in 3 cases of infectious arthritis resulted in relief of symptoms in 2 cases and precipitation of a severe attack in the third case. Although ordinary methods almost always show the fluid from the nonsecreting cyst to be sterile, there is clinical evidence that it may act as a toxic focus.

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3 Eichelberger, L., and Lindsay, J. R. Chemical Composition of Fluids from Benign Cysts of the Antrum, *Proc Soc Exper Biol & Med* **48** 191-195 (Oct.) 1941.

4 Grossman, J. W., and Waltz, H. F. Non-Secreting Cysts of the Maxillary Sinus, with Special Reference to the Roentgen Aspects and Diagnosis of the Large Types, *Am J Roentgenol* **52** 136-144 (Aug.) 1944.

5 Straus, G. D. Mucosal Cysts of the Maxillary Sinus, *Laryngoscope* **54** 267-276 (June) 1944.

5a Lindsay, J. R. Nonsecreting Cysts of the Maxillary Sinus Mucosa, *Laryngoscope* **52** 84-100 (Feb.) 1942.

*Clinical Course*—A cyst once formed may persist and increase in size until spontaneous rupture occurs. A very small cyst may disappear without the sudden unilateral discharge of fluid that would indicate rupture. On the roentgenogram the nonsecreting cyst appears as a dome-shaped shadow arising from the floor of the antrum. It may,



Fig 1—A, hyperplastic sinus mucosa. The fluid spaces seen in the subepithelial connective tissue layer may by confluence lead to the formation of a cyst. B, cystic polyp of the left maxillary sinus. An important diagnostic point in this film is that the lateral wall of the polyp stands away from the bony sinus wall (arrow), however, this situation is not present in all cases. C, the wall of a non-secreting cyst (case 1), stained with Mallory's connective tissue stain. The cystic cavity is lined by a layer of fibrous connective tissue. D, nonsecreting cyst in right antrum (arrow) (case 1).

however, fill the sinus and produce complete homogeneous clouding, which cannot be differentiated roentgenologically from empyema. There

is no alteration in the bony wall of the sinus, and a sinus containing such a cyst with minimal other pathologic changes generally may be transilluminated well. Millhon and Brown<sup>6</sup> recently reported finding dome-shaped cysts in the maxillary sinuses in 24 of 600 consecutive complete dental roentgenograms. They noted that 1 cyst had been present without change in size for six years, and yet that others had disappeared in a year. Wright<sup>7</sup> reported that round shadows in the maxillary sinuses were present in about 5 per cent of all roentgenograms of sinuses taken in a military hospital.

Large degenerating polyps may become cystic and give a roentgenologic appearance similar to that of the nonsecreting cyst. Differentiation is possible, however, in some cases, such as that illustrated in figure 1 *B*, in which the lateral wall of the polyp stands away from the bony wall of the sinus. Histologically, this growth proved to be a thick-walled, degenerating polyp with large central cystic spaces containing straw-colored fluid. A nonsecreting cyst presents a roentgenologic shadow of uniform density, whereas cystic polyps, because of their irregular shape, will sometimes create shadows of irregular density.

A fluid level is easily differentiated from a nonsecreting cyst by its flat horizontal surface and by the meniscus which can usually be seen. Also, the surface of a fluid level remains horizontal in all positions of the head, whereas the shadow of a nonsecreting cyst will not change its shape or position.

Dental cysts involving the antrum may create a roentgenologic shadow which may be confused with that of the nonsecreting cyst. A follicular (dentigerous) cyst which contains a tooth may be easily distinguished, however, when a tooth is not present, roentgenologic differentiation may be more difficult. Both follicular and radicular cysts destroy bone as they expand and may completely erode through one or more of the bony sinus walls, with resulting facial or intranasal deformity. Nonsecreting cysts, on the other hand, never affect the bony sinus wall. A radicular (root) cyst bulging up into the antrum may also have a more irregular upper border than has the nonsecreting cyst.

*Treatment*—Occasionally a nonsecreting cyst may disappear after spontaneous rupture or after puncture and lavage of the antrum. In many cases the removal of part or all of the cyst wall through an antrum window operation may result in a cure. Complete removal is sometimes necessary for a clinical cure. In cases in which there is also an

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6 Millhon, J. A., and Brown, H. A. Cysts Arising from Mucosa of Maxillary Sinus as Seen in Dental Roentgenogram, *Am J Orthodontics (Oral Surg Sect)* 30 12-15 (Jan) 1944.

7 Wright, R. W. Round Shadows in the Maxillary Sinuses, *Laryngoscope* 56 455-489 (Aug) 1946.

extensive hyperplastic change in the sinus mucosa it is necessary to perform a radical removal of the contents of the sinus, for which procedure the Caldwell-Luc operation is preferred

CASE 1—S S, a woman aged 57, had severe osteoarthritis of the spine. In a search for foci of infection, roentgenograms of the sinuses were made and revealed a dome-shaped shadow arising from the floor of the right antrum (fig 1 D). The patient had no local symptoms to indicate disease of that sinus. A curved punch was introduced into the cyst through the inferior meatus, and 6 cc of straw-colored fluid was removed. *Staphylococcus aureus* and *Staphylococcus albus* were cultured from this fluid. Three weeks later radical maxillary sinusotomy (Caldwell-Luc operation) was performed on the right side. The mucosa of the sinus was found to be decidedly hyperplastic and to contain numerous small retention cysts. There was a thick folded membrane, representing the collapsed cyst wall, in the floor of the sinus (fig 1 C). Recovery from the operation was uneventful. The patient was not kept under observation long enough for one to determine the extent of improvement of the arthritis. The case presented one of the rare instances in which organisms were cultured from the cyst fluid. It is possible that the cyst fluid or the culture mediums were contaminated.

The diagnosis was a nonsecreting cyst of the right maxillary sinus.

#### RETENTION CYST

Blockage of the duct of a tuboacinosal gland of the sinus mucosa results in a cystic dilatation of the gland by accumulating secretions. Such a cyst never becomes large. At operation the cyst is often described erroneously as a small abscess. It appears as part of the histopathologic picture in chronic inflammation or hyperplasia of the sinus mucosa, of either allergic or infectious cause.

*Pathologic Factors*—A number of these cysts were sectioned serially and the glandular duct examined histologically. There was usually pronounced hyperplasia of the normally columnar ciliated epithelium of the duct, which had become thick and pseudostratified, with resulting appreciable narrowing of the lumen of the duct. This situation is well shown in figure 2 A. The effect of toxins on ciliary action must be considered also as a cause of retention.

The wall of the cyst is lined with a single layer of cuboidal cells. Beneath this secretory epithelium is a loose connective tissue stroma, containing acute or chronic inflammatory cells in varying numbers (fig 2 B).

*Clinical Significance*—This cyst is apparently not symptomatic in itself, and it is not evident individually, either clinically or roentgenologically.

#### MUCOCELE

A mucocoele is an accumulation of the products of secretion, desquamation and inflammation within a paranasal sinus, with distention of the walls of the sinus. True mucocoeles occur typically in the frontal



Fig 2—*A*, duct of a retention (glandular) cyst *D* indicates a narrow, tortuous gland duct with hyperplastic epithelium, *N*, cuboidal epithelium of more normal-appearing ducts, and *R*, rupture of cyst wall with round cell infiltration *B*, the wall of a retention cyst The mucosa of the maxillary sinus is reflected over the top of the cyst

sinus and ethmoid cells, and more rarely in the maxillary or sphenoidal sinuses. Many cases described in the literature as those of mucocoele of the maxillary sinus have been instances either of a nonsecreting cyst or of a dental cyst. In our experience, over half the operations for chronic inflammatory disease of the frontal sinus were performed for the treatment of mucocoele.

*Pathologic Factors*—Obstruction of the nasofrontal duct or a particular ethmoidal ostium probably occurs in all cases of true mucocoele. Our experience indicates that blockage of the nasofrontal duct may occur temporarily in an acute episode without formation of a mucocoele. However, the recurrence of acute attacks associated in some instances with blockage apparently increases the probability of an eventual permanent blockage and formation of a mucocoele. In a comprehensive review of the literature, Wilkerson<sup>8</sup> noted that trauma, neoplasm and regional infections have been commonly considered etiologic factors in the narrowing and obstruction of these small passages. The dependent position of the ostium of the frontal sinus may be a predisposing factor in that during an acute attack with obstruction the products of inflammation accumulate at that point and predispose the opening to increasing fibrosis and stenosis. Whether or not the mucocoele always takes origin during an acute inflammatory episode is not definite. A slow, progressive blockage of the ostium and gradual replacement of air by the accumulating secretion and cellular debris might occur and explain the absence of the pain which usually occurs in cases of acute obstruction. Lobell<sup>9</sup> noted that apparent obstruction of the nasofrontal duct can occur without formation of the classic mucocoele. He expressed the belief that some form of cystic degeneration of the sinus mucosa must take place before a mucocoele develops.

Histologic examination of the wall of a mucocoele reveals that it is the distended mucoperiosteal lining of the sinus throughout. This is demonstrated in figure 3 *B*, *C* and *D*. The pseudostratified columnar epithelium normally seen on the surface is compressed into low columnar or cuboidal epithelium, with occasional goblet cells. There is a pronounced decrease in tuboacinos glands. The epithelium rests on a dense connective tissue wall of varying thickness, the stroma usually showing mild infiltration with small round cells.

*Symptoms*—There is usually a history of previous attacks of frontal or ethmoidal sinusitis. In some of these episodes there may have been swelling of the upper lid, or an orbital abscess may have been drained.

<sup>8</sup> Wilkerson, W. W., Jr. Mucocoele of the Nasal Accessory Sinuses, *Laryngoscope* 55:294-308 (June) 1945.

<sup>9</sup> Lobell, A. Relationship Between Mucocoeles and Cysts. Report of Cyst of Maxillary Sinus, *Arch Otolaryng* 6:546-551 (Dec) 1927.

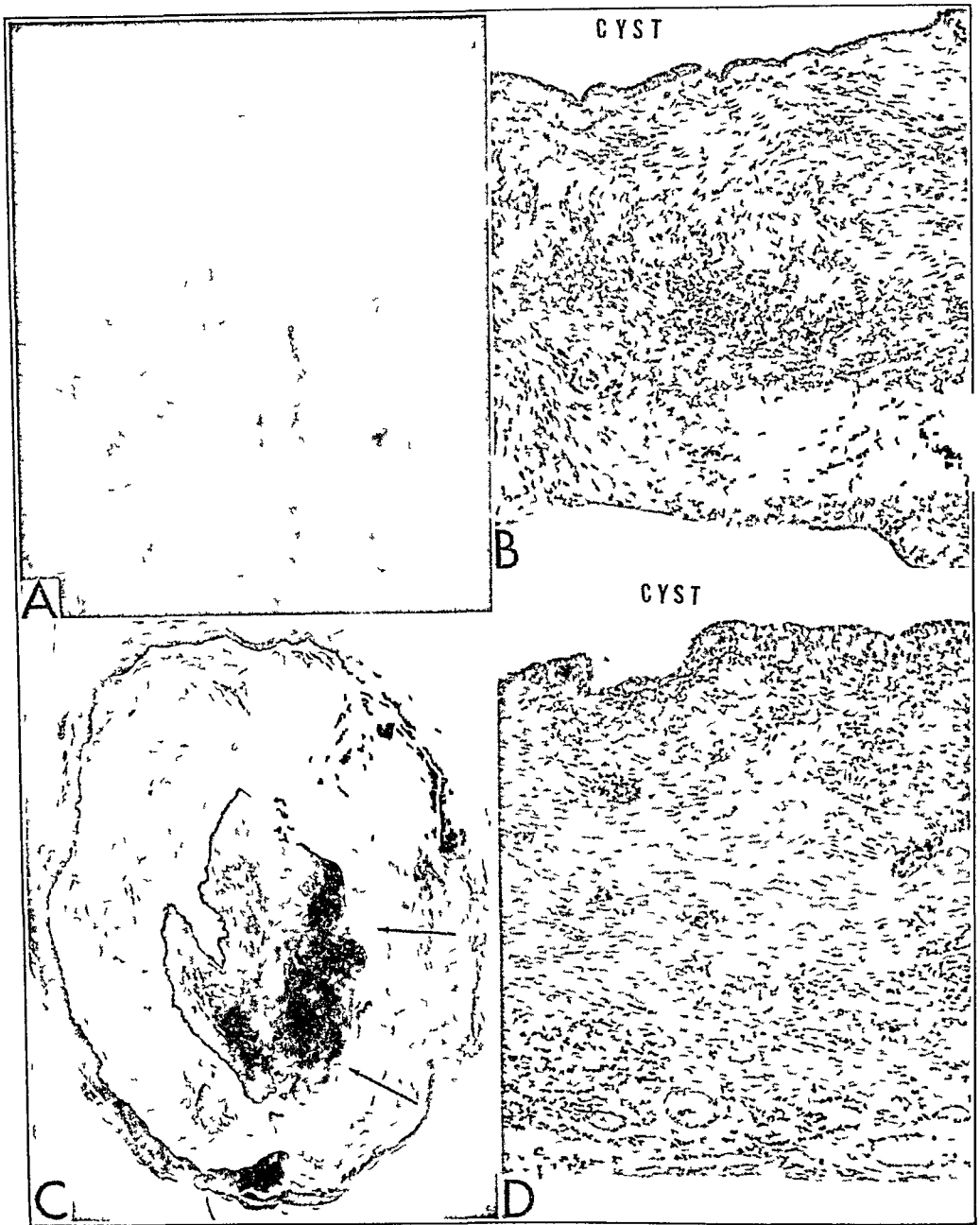


Fig 3—*A*, a mucocyst of the right frontal sinus. The bony walls have lost their septate appearance. There is a mild, bordering osteosclerosis. *B*, wall of the mucocyst shown in *A*. The epithelium of the sinus mucosa is conspicuously compressed. The subepithelial tissue consists of a thick layer of dense fibrous tissue infiltrated with lymphocytes. *C*, photomicrograph of another mucocyst of the frontal sinus which was removed intact. The mucoperiosteum of the sinus forms the wall of the cyst throughout. Part of the thickened wall has been displaced into the cyst. *D*, higher magnification of the wall of the mucocyst shown in *C*.

The development of the mucocele, however, is usually slowly progressive and the onset not clearly related to an acute attack. Generally the patient first notices a downward and outward displacement of the eye. Because the displacement is slow, diplopia develops only late, if at all. Visual impairment, limitation of movement of the globe and ptosis may occur. Nasal blockage on the involved side may result from expansion of the mucocele into the nasal passage.

*Chmical Findings*—As the mucocele increases in size, there is pressure erosion of the bony walls of the sinus, which often become so thin as to crepitate on palpation. This painless expansion may progress to involve the orbit, nasal cavity, anterior cranial fossa and anterior wall of the frontal sinus, with deformity of the forehead. Characteristically, there is palpable a tense elastic mass beneath the medial aspect of the supraorbital ridge. The eye is usually displaced forward, downward and laterally. Intranasal deformity is more commonly associated with ethmoidal mucocèles. Infection of the contents of the cyst may lead to a pyocele, with signs of acute inflammation (fig 4). Erosion of the posterior wall of the frontal sinus predisposes to the occurrence of an intracranial complication during an acute exacerbation.

Roentgenologic findings depend entirely on the size and location of the mucocele and the amount of deformity caused by it. The contents of the cyst render the cavity slightly less radiolucent than the normal, air-filled sinus, however, pressure erosion of the bony walls due to the expansion of the cyst may more than offset this added density.<sup>10</sup> In the early stages there may be mild osteosclerosis of the sinus wall, as a result of reactionary bone formation, but as the cyst increases in size the borders of the sinus lose their septate appearance, and the margins of the expanding cavity become smooth and rarefied until but a thin shelf of bone remains (fig 3 A).

*Treatment*—Mucocele requires surgical treatment. Those situated in the ethmoidal sinus and those of the frontal sinus which have expanded downward so as to involve the anterior ethmoidal cells may be suitable for an intranasal operation. However, in our experience, the number which can be treated in this way is small. In most cases an external frontal sinusotomy has been required for sufficient exposure. An essential part of the surgical treatment of mucocele of the frontal sinus is the complete removal of the remaining parts of the floor of the frontal sinus and all frontoethmoidal cells. In most cases, the anterior ethmoidal cells have been at least partly involved, and the nasofrontal duct has been irreversibly damaged. It is necessary then to do an exenteration,

<sup>10</sup> Hartung, A., and Wachowski, T. Mucocele of the Frontal Sinus, with Special Reference to Roentgen Aspects and Report of Four Cases. *Am J Roentgenol* 34 30-36 (July) 1935.





Fig 4—Infected mucocoele of the left frontal sinus (pyocoele) (case 4)

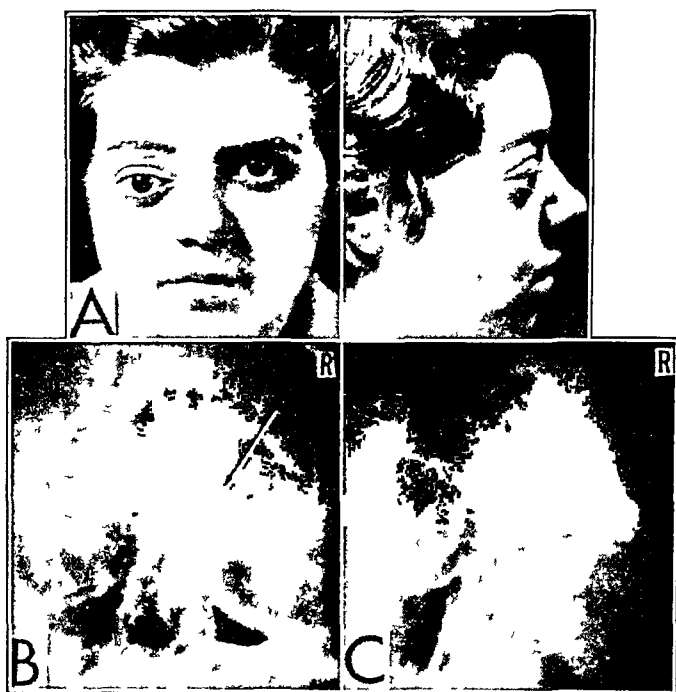


Fig 5—*A*, mucocoele of the frontal sinus (case 2) Preoperative views show the typical proptosis and downward and lateral displacement of the right eye *B*, a preoperative roentgenogram of mucocoele of the frontal sinus (case 2) There is complete absence of the middle two thirds of the right supraorbital ridge *C*, a roentgenogram in the same case two months after operation, showing the right frontal sinus completely filled with iodochlorol® (chloriodized peanut oil, representing 27 per cent of iodine and 75 per cent of chlorine) The outline is sharp and in direct contact with the bony walls

being careful to remove all parts of the floor of the frontal extensions of the ethmoidal cells, as well as those of the floor of the frontal sinus. A large opening is then provided into the nose through the enlarged nasofrontal duct and anterior ethmoidal cells. Experience has shown that in some cases there is a tendency to postoperative closure of this nasofrontal opening. Poor drainage, with a tendency toward chronic suppuration, is the result. Because of the tendency to closure and recurrence of suppuration, it is essential that the surgical steps be carried out as carefully in the case of a mucocele as in that of chronic suppuration of the frontal sinus.

CASE 2—B J, a girl aged 16, first came to the ear, nose and throat clinic with the history that her right eye had begun to protrude eleven months before and that the condition was becoming worse. There were now headaches in the right frontal area.

At the age of 6 the patient had had an infection of the upper respiratory tract, after which the right eye had become swollen and red. Incision of the upper lid had been followed by purulent drainage. This history suggested acute suppurative ethmoiditis and orbital cellulitis. However, the age of the patient did not preclude acute frontal sinusitis as well.

Examination revealed proptosis and lateral and downward displacement of the right eye (fig 5A). There was diplopia on left lateral gaze. Palpation revealed a defect in the medial two thirds of the supraorbital ridge. In this region and in the superior medial aspect of the orbit was a firm, elastic, nontender mass. Roentgenograms of the sinuses revealed complete absence of the medial two thirds of the supraorbital ridge (fig 5B and C).

An external frontal sinusotomy was done, revealing a cystic cavity filled with mucopurulent material. The cyst lay partially within the orbit and had obliterated part of the anterior ethmoidal cells and the nasofrontal duct. A wide opening was made from the nasal fossa directly into the cystic cavity, the cystic lining being left in place. Because this nasofrontal opening had a tendency to close, the patient used a nasofrontal duct dilator at home for several months. Recovery was otherwise uneventful.

The diagnosis was a mucocele of the right frontal sinus.

CASE 3—B H, a woman aged 33, was first seen by us on Feb 8, 1940. She gave the history of having had right-sided headaches and swelling around the right eye at the age of 15. At the age of 16 she had had an intranasal operation but had experienced no relief from symptoms. The following year an external nasal operation had been performed on the right frontal sinus and had given relief from headaches. For the past five years she had noted gradual displacement and loss of vision in the right eye. One month prior to admission the right-sided headaches had recurred.

The patient presented the pronounced facial deformity seen in figure 6B. The right nasal cavity was filled with a large bulging mass, pushing the nasal septum to the left. There was a complicated cataract of the right eye, and the patient could detect only hand movements at 3 feet (90 cm). Roentgenologic examination (fig 6A) revealed a multilocular lesion of the right frontal sinus, which extended into the orbit, nasal cavity and maxillary sinus on that side and bulging into the anterior cranial fossa. The right frontal bone was thickened above the lesion (chronic proliferative osteomyelitis).

On February 14, an external radical frontoethmoidal sinusotomy was performed on the right side, revealing a huge cavity in the frontal and ethmoidal area, the cavity was filled with a large cyst containing a thick, mucoid secretion. The cyst extended into the orbit and the maxillary sinus. The remaining ethmoidal cells were removed. The dura was exposed widely. A wide opening was left from the nasal fossa into the cystic cavity. Cultures grew *Staph aureus* and *Staph albus*.

Recovery was uneventful.

The diagnosis was mucocele of the right frontal sinus, encroaching on the ethmoidal and maxillary sinuses and the anterior cranial fossa.



Fig 6—*A*, mucocele of the right frontal sinus (case 3). There is expansion of the cyst into the orbit, nasal cavity, maxillary sinus and anterior cranial fossa. The frontal bone is thick and sclerotic above the right frontal sinus (chronic proliferative osteomyelitis). *B*, photograph of the patient in case 3, showing the displacement of the right eye and deformity of the frontal area.

CASE 4—*A* L., a man aged 26, when first seen on June 28, 1930, gave a history of having received a blow to the forehead two years previously, after which injury he had had a swelling and much pain over the left eye. Since that time, he had had headaches in the left frontal area. These had occurred about once a month and had lasted two or three days. One month prior to consultation the headache had been accompanied with swelling of the left upper eyelid. The only finding was pus in the left middle meatus. The roentgenogram showed complete clouding of the left frontal sinus and partial clouding of the left antrum. A purulent

secretion was obtained repeatedly on lavage of the antrum. A nasoantral window was made on the left side, after this operation the patient was free of symptoms until 1938 (eight years), when he began again to have occasional headaches in the left frontal area, accompanied occasionally with swelling of the left upper eyelid.

On July 23, 1942, there developed a tender, red, edematous swelling of the left frontal area and upper eyelid with constant, severe pain localized to that area and accompanied with fever and malaise (fig 4). Roentgenologic examination revealed clouding and an irregular outline of the left frontal sinus, with decided sclerosis around the border. Vision was normal, and the fundi were clear. The general physical and neurologic examination revealed an essentially normal condition.

An external radical frontal sinusotomy was performed the following day. A large, pus-containing cavity was opened. There were granulations on the posterior wall. At this point the bony wall was dehiscent, and a large abscess cavity in the anterior cranial fossa was exposed. The extent of the abscess cavity could not be definitely determined. The anterior ethmoidal cells were completely exenterated, care being taken to remove any remnants of the floor of these cells and of the frontal sinus. Cultures grew hemolytic streptococci and *Staph aureus*. There was drainage of cerebrospinal fluid from the sinus for about two weeks after operation. Sulfadiazine was given in sufficient amounts to maintain a high concentration in the blood during this time.

Recovery was uneventful. However, five years later, puffiness of the left eyelid occasionally appeared in the mornings during head colds, and there was a periodic purulent discharge from the frontal sinus.

The diagnoses were (1) acute infection of a mucocoele (pyocoele) of the left frontal sinus and (2) extradural abscess of the left anterior cranial fossa.

#### MUCOCELE AND PROLIFERATIVE OSTEOMYELITIS

The occurrence of a mucocoele along with the extensive proliferation of new bone is not unusual. In the past it was generally thought that in such cases an osteoma of the sinus had caused blockage of the nasofrontal duct with resulting mucocoele or that possibly the development of the mucocoele and the osteoma were independent. In some instances the history and clinical findings seem to indicate that the proliferation of bone has been secondary to the inflammatory process. Maxwell<sup>11</sup> recently presented a series of 8 cases of chronic proliferative osteomyelitis of the skull, in 6 of which the condition was secondary to sinus infections. A mild degree of chronic proliferative osteomyelitis is illustrated by case 3 (fig 6A).

Case 5 in this series is presented as an example of extensive proliferation of new bone along with an infected mucocoele. The widespread distribution of the new bone within the sinus and the dissemination of the purulent discharge in pockets throughout the new bone indicated that the osteogenic process was secondary to the inflammatory reaction. In this case proliferative osteomyelitis seemed the correct interpretation on clinical observation. The histopathologic observations supported this diagnosis.

<sup>11</sup> Maxwell, J. H. Chronic Proliferative Osteomyelitis of the Skull, *Ann Otol, Rhin & Laryng* **55** 719-742 (Dec.) 1946.

CASE 5—M. C., a woman aged 46, when first seen by us on April 6, 1946, stated that she had been struck on the forehead by a door eight months previously. Three months later she had noted a swelling over the right frontal area and of the right upper eyelid and for the past month had had an aching pain in that area. She had no nasal discharge.

On examination the bone over the right frontal sinus was tender and bulged considerably. A smooth, elastic, tender mass was palpable beneath the right supra-orbital ridge and displaced the eye downward and laterally.

Roentgenologic examination showed evidence of pronounced sclerosis of the right frontal sinus. The peripheral margins of the sinus throughout appeared hazy and sclerotic (fig 7 *A*). The pain and tenderness in that region subsided on administration of 1 Gm. of sulfadiazine four times a day.

An external radical frontal sinusotomy was performed on the right side on April 24. The frontal bone was found to be considerably thickened. A large mass

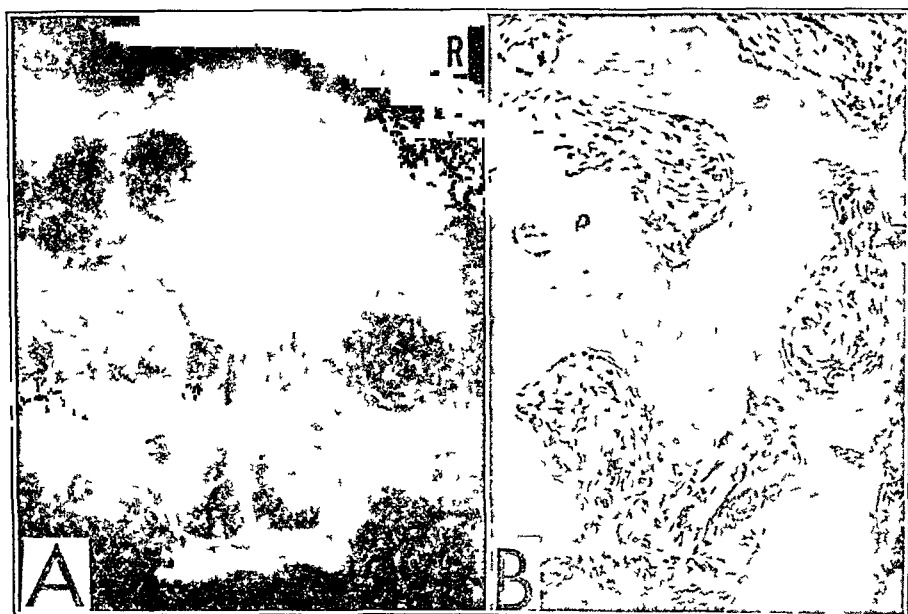


Fig 7—*A* (case 5), mucocoele of the right frontal sinus associated with chronic proliferative osteomyelitis of the frontal bone. The cyst had expanded into the orbit. It contained mucopus and a mass of new bone. *B*, photomicrograph of new bone removed from the frontal sinus in case 5. The bone trabeculae are lined with osteoblasts. Between the bone trabeculae is a vascular fibrous tissue richly infiltrated with small round cells.

of soft cancellous bone almost filled the sinus and appeared to be attached on wide bases to both the anterior and the posterior wall. Over the entire extent of the sinus walls was a soft layer of new bone, which was scooped out with a large bone curet. Small pockets of pus were dispersed throughout this new bone. The rest of the sinus was filled with mucopus. The cyst protruded into the orbit through a defect in the floor of the sinus. The anterior third of the middle turbinate body was amputated, the anterior ethmoidal cells were removed, and a wide opening was made into the nose.

There was diplopia on left lateral gaze for about five months after operation. When last seen by us, one year after operation, the patient was free of symptoms, and the right eye had returned to its normal position.

The diagnosis was chronic infection of a mucocoele in the right frontal sinus with chronic proliferative osteomyelitis of the frontal bone (A microsection of the new bone growth is seen in fig 7B)

### ODONTOGENIC CYSTS

A review of dental embryology is presented for the purpose of clarifying the histogenesis of follicular and radicular cysts

Tooth development begins by extension of the dental lamina down into the primitive gum, where knoblike thickenings occur. These form into inverted cup-shaped structures, having an inner and an outer enamel epithelium, separated by a filling of looser cells, the stellate reticulum (fig 8A). Specialized connective tissue cells, the odontoblasts, arise from the thickened mesenchyme beneath the deeper side of the enamel organ and are concerned with the formation of dentine. Then, as enamel is laid down on the dentine, the stellate reticulum disappears, and the outer enamel epithelium loses its separate identity.

Follicular cysts develop from enamel organ epithelium around the crown of the tooth. The cause of the development of the cyst is not definitely known. One theory is that it forms by dissolution of the stellate reticulum and distention of the dental follicle.

As the tooth develops, there is a downward extension of the enamel epithelium over the upper part of the dental papilla, thus forming Hertwig's sheath (fig 8B). It has conclusively been shown that remnants of this epithelial sheath may persist in the periodontal membrane after tooth development is completed. The epithelium in an apical granuloma is probably derived from these cell nests (debris of Malassez). Inflammatory stimulation causes the epithelium to proliferate in the form of strands, which may ramify in the granulation tissue (fig 9A). The tendency of the epithelium to grow on a surface often results in its forming a complete lining of an abscess cavity.

Radicular cysts may develop from these apical granulomas, whether or not these cysts have an epithelial lining depends on whether or not epithelial rests have been caught in the granuloma (fig 9B).

The formation of a cyst depends on the following factors: (1) central dissolution of the granuloma, (2) transudation of fluid through the cyst wall, (3) absence of spontaneous drainage by formation of a fistula and (4) a mild clinical course without surgical intervention.

### FOLLICULAR CYST

The follicular cyst is derived from enamel organ epithelium and usually contains the crown of a tooth in its wall. It occurs more frequently in the mandible than in the maxilla. This cyst may arise from any of the permanent or deciduous teeth but has origin most commonly in the enamel organ of the third molar. When a tooth is present in its

wall, the cyst is commonly termed a dentigerous cyst. Occasionally there are multiple cysts or multiple teeth in one cyst. There will be no tooth in the cyst wall if the cyst develops from the enamel epithelium before it has become sufficiently differentiated to form enamel.<sup>12</sup>

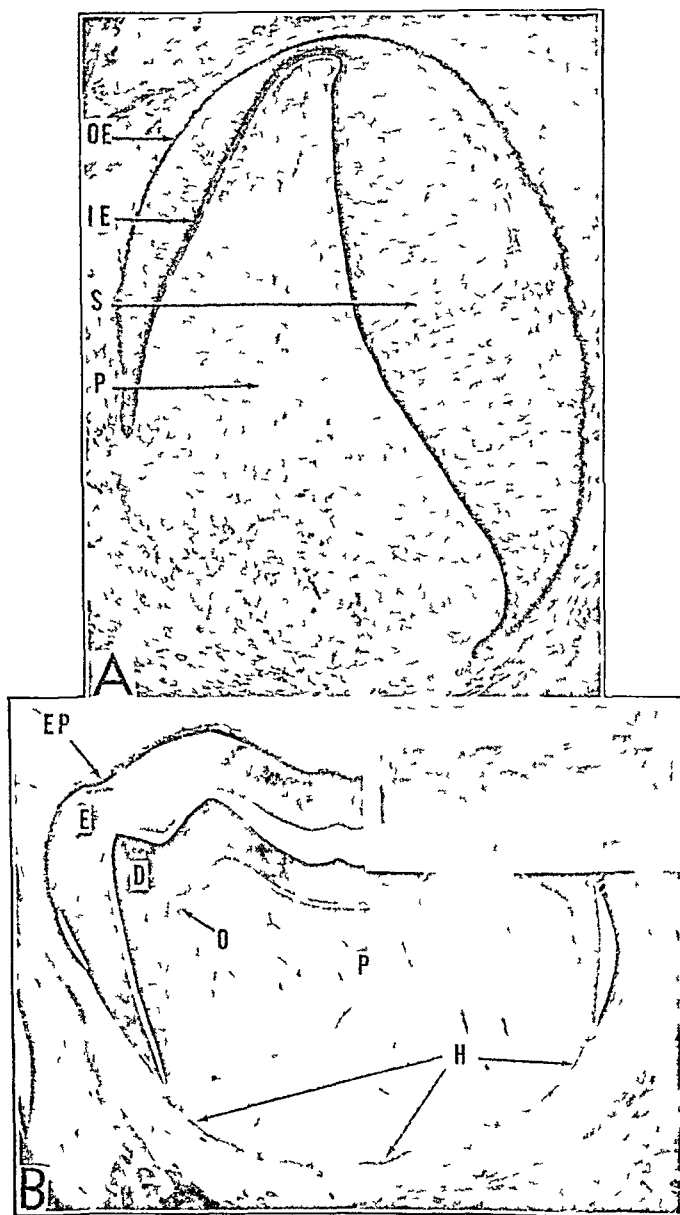


Fig 8—*A*, an early tooth bud in a newborn infant. *OE* signifies the outer enamel epithelium, *IE*, the inner enamel epithelium, *S*, the stellate reticulum and *P*, the dental papilla. *B*, a developing molar in a 4 month old infant. *EP* signifies enamel epithelium, *D*, dentine, *E*, enamel, *O*, odontoblasts, *P*, dental papilla, and *H*, Hertwig's sheath. Inset, a high power view of the epithelium of Hertwig's sheath.

<sup>12</sup> Thoma, K. H. *Oral Pathology: A Histological, Roentgenological, and Clinical Study of the Diseases of the Teeth, Jaws, and Mouth*, St. Louis, C. V. Mosby Company, 1941.

The cause of this maldevelopment of the dental follicle is not known

*Pathologic Factors*—The cyst wall consists of a connective tissue capsule, of varying density, and a lining of stratified squamous epithelium. There is usually an infiltration of small round cells into the sub-



Fig 9—A, an epitheliated apical granuloma. R signifies the tooth root, G, the granulation tissue, and C, a small cystic space lined with epithelium. B, a non-epitheliated apical granuloma. G signifies the fibrosing granulation tissue, and C, the nonepitheliated cystic space.

epithelial connective tissue. When a tooth is present, the epithelium is usually attached to the neck of the tooth, with the crown projecting into the contents of the cyst. As the follicle expands, the tooth may be



displaced far from its original site. It was shown by Cahn<sup>13</sup> that there may be transition from this simple odontogenic cyst to adamantoblastoma.

*Symptoms*—There often are no symptoms until the cyst is so large as to cause deformity of the alveolar process, palate or face. Pain, if present, is usually minimal and, when due to pressure on nerves, may be referred to other parts of the face.

The cyst may invade, completely fill and expand the walls of the maxillary sinus. The cyst may become infected.

*Clinical Findings*—Facial or nasal deformity may occur when the follicular cyst is so large as to fill the maxillary sinus and expand its walls. An additional clinical finding in some cases is the absence of a tooth on the involved side.

The typical roentgenologic picture of the alveolar process is that of a rounded area of destruction of bone with smooth borders and containing a tooth. When the antrum is involved, a shadow of increased density is seen to bulge up from the floor. The tooth, when present, is often displaced into the sinus. As the follicular cyst becomes larger, one or more of the bony sinus walls may become thin, smooth and expanded.

*Treatment*—The treatment is complete surgical removal of the follicular cyst and its contents. Care should be used in removing all the cyst wall, as it may be adherent to the bony wall of the sinus in some areas. The removal is usually best accomplished by the Caldwell-Luc operation.

CASE 6—H. G., a man aged 20, complained only of recent pain in the right side of the face. Clinical examination revealed a bulging inward of the lateral wall of the right nasal passage. The right third molar tooth had not erupted.

Roentgenologic examination revealed complete clouding of the right maxillary sinus. A shadow having the general contour of a tooth lay in the posterolateral angle of the sinus (fig. 10 B and C).

A radical antrotomy was performed on the right side. The bony wall in the region of the canine fossa was thin. The cyst wall was tough and under tension. It was needled, and 20 cc of thick viscid material was removed. The wall of the cyst was adherent to the floor. A large tooth projected into the cyst from the posterolateral wall near the floor. It was removed with the cyst wall without difficulty. There was no bone in the nasoastral wall below the inferior turbinate process. A large window was made into the nose through the inferior meatus. A section through the wall of the cyst is seen in figure 10 A.

The diagnosis was a follicular (dentigerous) cyst of the right third molar tooth, filling the right maxillary sinus.

#### RADICULAR CYST

The radicular cyst develops at the root of a tooth, in contradistinction to the follicular cyst, which develops around the crown. As

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13 Cahn, L. R. The Dentigerous Cyst as a Potential Adamantinoma. *Dent Cosmos* 75:889-993 (Sept.) 1933.

previously stated, the radicular cyst probably develops from central necrosis of an apical granuloma. The occurrence of an apical granuloma secondary to infection of the pulp canal is common. When the acute inflammatory reaction is mild, the condition may go untreated and the granuloma increase in size. Central dissolution may take place by abscess formation or possibly may be due to a vascular disturbance.

*Pathologic Factors*—Occasionally the centrally degenerated apical granuloma will proceed to formation of a cyst if not interfered with. Epithelial rests from Heitwig's sheath may be caught in this granuloma and under stimulus will partially or completely line the cystic space. The epithelium is the stratified squamous type and closely resembles oral

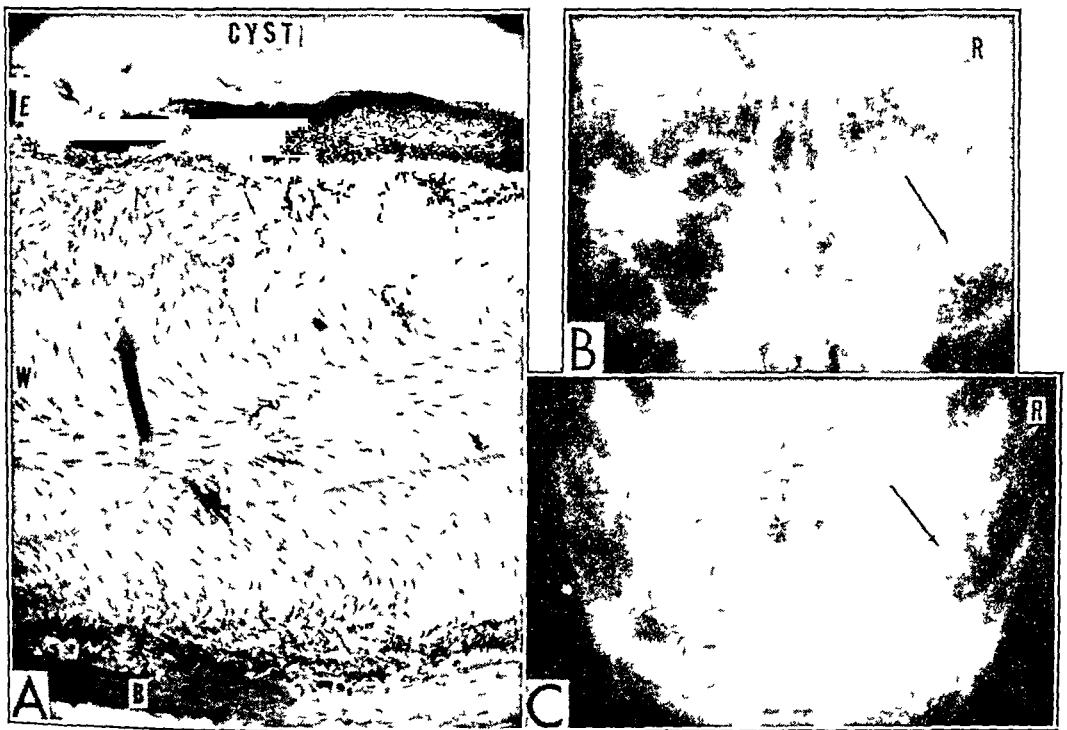


Fig 10—*A*, wall of a follicular cyst (case 6). *E* indicates stratified squamous epithelium lining the cyst, *W*, dense fibrous tissue wall, and *B*, a small sliver of bone from the surrounding bony wall. *B*, follicular cyst of the right maxillary sinus (case 6). The tooth has been displaced into the posterosuperior aspect of the right maxillary sinus (arrow). *C*, axial view (case 6). The arrow indicates a tooth.

epithelium. As stated before, whether or not radicular cysts are epithelized depends on whether or not paradental epithelial debris is present. The cyst fluid consists of inflammatory exudate, necrotic tissue and cholesterol crystals. The wall consists of a connective tissue stroma of varying density, richly infiltrated with small round cells and some small blood vessels. The degree of cellular infiltration and fibrosis of the cyst wall is determined by the amount of inflammatory reaction and the age of the cyst. As the cyst expands, resorption of

bone takes place. Outside this zone of bone resorption, however, new bone is usually laid down, so that as the cyst bulges up into the antrum a thin shell of bone may cover it.

*Symptoms*—Symptoms are usually minimal, however, there may be toothache and pain over the side of the face. As the cyst expands downward through the alveolus, a tender swelling of the gum may result. Rupture may occur, with drainage of the contents of the cyst into the mouth. The cyst may develop after the offending tooth has been removed. One might assume that in such a case an infected root

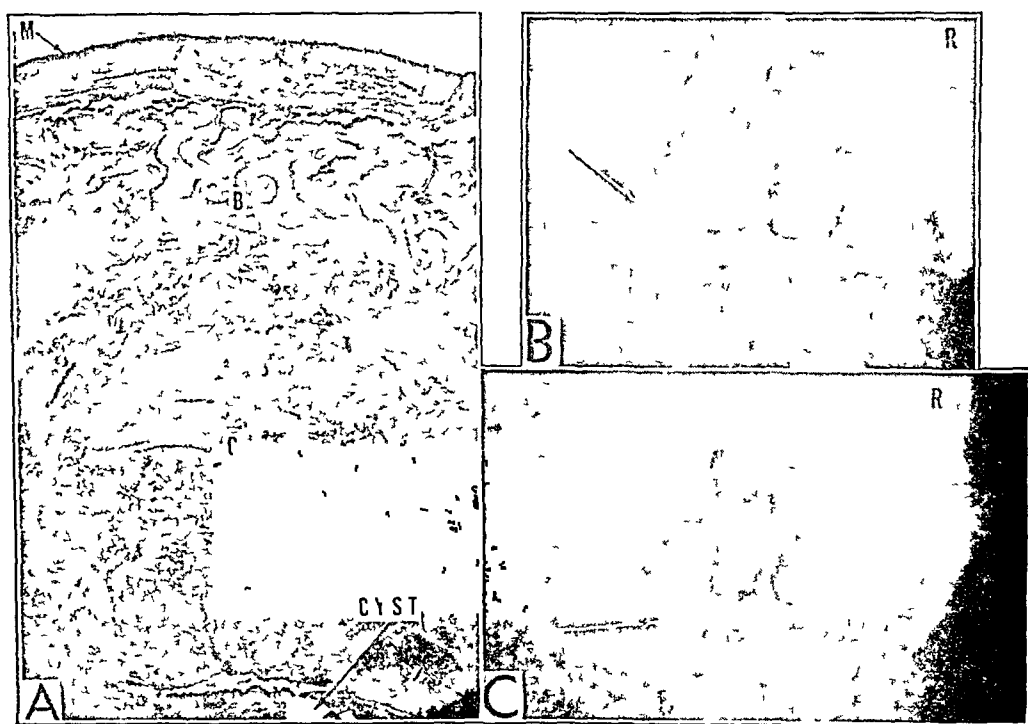


Fig 11—A, wall of a radicular cyst (case 7). M indicates the mucosa of the maxillary sinus, B, the bony capsule, and G, granulation tissue. B, radicular cyst (case 7). There is a dense shadow extending from the alveolar process up into the left maxillary sinus (arrow). C, roentgenogram in the same case, with iodized oil U S P outlining the cystic space.

fragment had been left in the alveolar process or that a pyogenic granuloma had persisted after extraction of the tooth.

*Clinical Findings*—Swelling and tenderness over the involved maxillary sinus or of the gum may be present. Dental roentgenograms reveal the round area of bone destruction in the alveolar process, usually around the root of a tooth. When the antrum is involved, roentgenograms of the sinuses reveal a dense, homogeneous shadow bulging up from the floor. This shadow may be so large as to involve the entire sinus.

*Treatment*—Offending teeth which remain should be extracted. It is essential to remove all diseased tissue from the alveolar process. If the maxillary sinus is infected or extensively occupied, it should be exenterated, for which procedure a Caldwell-Luc approach is most suitable. Care should be taken to create a nasoantral window which will remain open.

CASE 7—M. K., a woman aged 40, complained of pain and swelling, of three days' duration, in the region of the left cheek. All the left upper teeth had been removed one year previously, without event. Examination revealed tenderness and puffiness of the left cheek over the left maxillary sinus. There was a red, tender and fluctuant mass, the size of a hazelnut, on the buccal aspect of the gum in the left upper premolar region. Purulent material was aspirated and iodized oil U S P injected into the cyst.

Roentgenograms revealed a poorly defined mass extending from the floor up into the left maxillary sinus. Injection of iodized oil U S P outlined a large cyst extending from the alveolar process up into the sinus (fig 11 B and C).

One month later, with the use of local anesthesia, a mucoperiosteal flap was raised to uncover the left alveolar process in the area from the first bicuspid to the third molar. The wall of the cyst was dense and adherent to the floor. There was only a thin shell of bone over the dome and the lateral walls of the cyst. The cyst was completely removed by curettage.

A photomicrograph of the cyst wall is seen in figure 11 A. In this case the cystic space was not epithelized.

The diagnosis was a radicular cyst invading the left maxillary sinus.

## SUMMARY

Benign cysts of the paranasal sinuses may be divided into two groups, those arising from the sinus mucosa and those of dental origin.

Three types arise from sinus mucosa:

1. Nonsecreting cysts, found in the maxillary sinus. They arise in the connective tissue layer as a result of chronic inflammation and contain straw-colored fluid of high protein content. As they become large, both local and general toxic symptoms may be produced. They have a thin wall and rupture before causing deformity.

2. Small retention (glandular) cysts. These are common in hyperplastic sinus mucosa and are probably due to obstruction of the duct by hyperplastic epithelium. They occur as part of the pathologic process in chronic inflammatory disease of the sinuses, they are not individually evident in roentgenograms but may be seen during surgical removal of the mucosa.

3. Mucocèles. These are commonly found in the frontal and ethmoidal sinuses. They are apparently due to obstruction of the outlet of the sinus into the nose. They erode the bony walls and may produce facial deformity.

Benign cysts of dental origin which may involve the maxillary sinus are as follows

1 Follicular cysts These arise from the enamel organ epithelium, may or may not contain teeth, may encroach on the maxillary sinus and nasal cavity and may produce external deformity

2 Radicular (root) cysts These develop from apical granulomas and may or may not have an epithelial lining

The microscopic sections for figures 8 and 9 were supplied by Dr James R Blayney, Zoller Dental Laboratory, the University of Chicago

## MIXED TUMOR OF THE REGION OF THE HEAD

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BOSTON

THE TERM "mixed tumor" has appeared in the literature and has been used in general discussions of tumors of the region of the head for years. Because of the partial misnomer, "mixed," the nature and the characteristics of the tumor have become confused, and an approach to the problems which cases of tumor of this type present has, on some occasions, not been clearcut. The tumor has been found in the salivary glands, the buccal mucosa, the palate, the lips, the neck, the orbit, the lacrimal gland and the face. However, the term is also used to include any tumor in any other part of the body which contains comparatively simple, chiefly embryonal growths of purely local origin, resulting from an overgrowth of embryonal structures with or without displacement. Most of the accepted forms of the tumor do not contain derivatives of the three germ layers, but are bidermal or monodermal. According to this concept, teratoma obviously falls into this group, but Ewing<sup>1</sup> has stated that the term "teratoma" should be used when the structure is more complete and rudimentary organs are present. Hence, by generally accepted definition, a mixed tumor is a complex embryonal tumor of local origin which reproduces the normal development of the tissues and organs of the affected part. It was recognized as early as 1879 that this type of tumor is of a highly complex structure. It usually presents epithelial elements in the form of cell strands, alveoli or diffuse masses, and mesoblastic tissues—chiefly cartilage and mucous and cellular connective elements. Any one of these tissues may predominate and give a nearly pure chondroma, sarcoma or carcinoma, but usually all the cell types are present.

In a series of studies Krompecher<sup>2</sup> reached the conclusion that the mixed tumor of the salivary gland belongs to a class of basal cell carcinomas. In the soft, pliable stroma of the growth he found that the

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From the Department of Otolaryngology, Massachusetts Eye and Ear Infirmary.

<sup>1</sup> Ewing, J. *Neoplastic Diseases. A Treatise on Tumors*, ed. 3, 1928, Philadelphia, W. B. Saunders Company, p. 773.

<sup>2</sup> Krompecher, E. *Beitr. z. path. Anat. u. z. allg. Path.* **28**: 1-41, 1900.

epithelial cells readily split off, fibrillate and assume the spindle or the star shape of mucoid or embryonal connective tissue cells. Under these conditions true connective tissue and, by further metaplasia, cartilage may be derived from basal epithelium.

Briefly, the present status of knowledge concerning the mixed tumor of the salivary gland, according to Ewing,<sup>3</sup> may be summarized as follows:

1 The theory of strict endothelial origin has been disproved.

2 No single source of the mixed tumor meets all the requirements. In some instances it is distinctly adenomatous and probably arises from the acini and ducts of the glands in which it is well incorporated. In still other cases it is encapsulated or extraglandular and takes the form of basal cell epithelioma. Probably in these instances it arises from misplaced and occasionally embryonal portions of gland tissue. Branchial remnants may possibly be connected with this group.

3 That mucous tissue and cartilage may derive from gland epithelium has been satisfactorily proved, and there is no necessity of including in the primary tissue any cartilaginous structures.

#### ANATOMIC ASPECTS

The gross anatomy presents many variants. The usual beginning is a small firm nodule in or on the salivary gland, a nodule which remains within a well defined capsule until it reaches considerable size. Fusion with the septums of the gland is commonly observed, and in the lobulated tumor the dividing trabeculae may be continuous with the interlobular septums. If small, the tumor may be completely separable, if large, it shows increased fusion, or it may be incorporated in the gland from the onset. Only occasionally is it possible to excise the tumor without including fragments of the gland. Frequently there is no obvious connection between the tumor and any gland. In some instances it develops along Stensen's duct, in others it may appear below or behind the ear and seem to involve the aural cartilage, while in a few cases it is found well below the submaxillary gland. It may appear in the retropharyngeal region or in any part of the lateral wall of the pharynx or the floor of the mouth. In consistency it is usually quite firm, but the cellular and mucoid type of growth may be soft and elastic. Small cysts are frequently encountered, and very rarely the tumor may consist of one large cyst. Cross section reveals opaque cellular areas, which may be vascular, softened, gelatinous masses, exuding mucus or serum, likewise, hard fibrous or hyaline zones or areas of cartilage and,

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<sup>3</sup> Ewing,<sup>1</sup> p. 775

very rarely, bone are seen. In almost all instances the tumor shows evidence of mucous secretion. Predominance of one element may give an almost pure myxoma, chondroma, fibroma, carcinoma or sarcoma.

#### CLINICAL COURSE

It is obvious both from reports in the literature and from clinical observation that in the vast majority of cases an observable but small tumor has long preceded the period of active growth. In our series there was an average period of quiescence of seven years. It is interesting to note that Wood<sup>4</sup> reported an inactive period of fifty-three years in a case which he observed. Following the initial appearance and quiescence, the tumor enters on a stage of active growth. The speed with which the mass increases in size is apparently dependent on the histologic type, although a limitless growth is not necessarily an attribute of this tumor, since it may continue to increase in size for several years and then enter another quiescent stage.

The only constant factor in the clinical behavior is, paradoxically, the wide variation in the cycle of growth, which is unpredictable. Occasionally, the growth is steadily progressive and rapid, highly infiltrative and possessed of all the characteristics of cancer. Fortunately, the incidence of this type is low. At the other end of the growth spectrum are those forms which remain encapsulated and the growth of which is such a slow process that the patient lives a normal span of life and dies of other, unrelated pathologic conditions.

When a mixed tumor has reached sufficient size, its presence is known by two factors: (1) pressure phenomena and (2) cosmetic distortion. Since the facial nerve lies below the parotid gland and in this region the incidence of the tumor is 51 per cent of those studied, it would be reasonable to assume that the facial nerve should show distortion of function in a high percentage of cases. This, however, is not a demonstrable fact, the incidence in the series observed at the Massachusetts Eye and Ear Infirmary being only 0.1 per cent of cases. But involvement of this nerve is a constant potential danger, though fortunately it takes place quite slowly. The undisturbed tumor rarely invades the lymph nodes, but after an unsuccessful operative procedure, while the recurrence is usually local, the regional glands may become involved. As do many other types of tumor, the mixed type most frequently manifests itself by anatomic distortion, and it is this symptom alone which causes the patient to consult the physician.

One fact concerning the clinical course is most significant—no patient complains of pain.

<sup>4</sup> Wood, F. C. *Ann Surg* 39: 57 and 207, 1904.



## INCIDENCE

During a period of ten years 61 patients were operated on for mixed tumor in the Tumor Clinic of the Massachusetts Eye and Ear Infirmary and Massachusetts General Hospital. An analysis follows:

Total cases of mixed tumor—61

Cancerous 7

Noncancerous 54

Position of tumor—

Parotid gland	30	{	Massachusetts General Service	20
Submaxillary region	8		Massachusetts Eye and Ear Infirmary Service	10
Palate	7			
Lacrimal gland	3			
Jaw	3			
Tear sac	2			
Neck	2			
Tongue	2			
Cheek	2			
Tonsil	1			
Pharynx	1			

## COMPLICATIONS

The facial nerve was involved prior to operation in 2 cases and after operation in 7, there was weakness, not complete paralysis, in the distribution of the branches of the nerve. There was recurrence in 4 cases—in all of which the tumor was noncancerous. There was no case in which salivary fistula developed.

## TREATMENT

In theory the prognosis following treatment should be excellent, because of the fact that the tumor is so predominantly benign. However, the facts do not uphold this theory, primarily because the treatment afforded the mixed tumor has had little or no plan, has been inadequate or has been directed along the wrong path of attack. Roentgen ray treatment is a glaring example of the latter. In spite of many articles condemning this practice, one finds in certain places a reliance on this therapy. Roentgen therapy for the mixed tumor should be thoroughly condemned for two reasons. First, the tumor is highly resistant to radiation, and hence no real effect is secured, second, the consequent fibrosis, induced by the roentgen rays, causes difficulty without end for the surgeon when finally the patient submits to operation.

If the tumor involves structures about the head and neck other than the parotid gland, its removal is generally attended by no great difficulty and, as a rule, falls into the classification of routine procedures. If the tumor involves the parotid gland, however, it is in another category.

because of the anatomic relationship between the gland and the facial nerve. In attacking any problem involving a tumor, the primary purpose of the surgeon is to excise completely or eradicate all tumor cells, for, if this is accomplished, absolute cure is established, at least in theory. My associates and I believe that this should be kept in mind at all times, particularly in relation to the parotid gland. Because the facial nerve is in close proximity, much incomplete surgical intervention has been done, and the recurrence rate for a normally benign tumor of this region is absurdly high—as much as 20 per cent (Ahlbom<sup>5</sup>) in some series. Why is it that the recurrence rate in other sites is very low? The answer must be in two words—complete excision. It appears that if this is to be accomplished the surgeon must direct his efforts toward this end in spite of the barrier of the facial nerve.

In general the cases may be grouped clinically as instances of the encapsulated and instances of the infiltrated type. With the encapsulated type the usual mode of attack is to evacuate the content and go no further. It is important to remove the capsule completely and to avoid scattering tumor cells in the exposed area. Bailey<sup>6</sup> advised flooding the wound with 60 per cent alcohol before closure in order to destroy cells which may become centers of recurrence. As a rule this type presents no great difficulty with branches of the facial nerve. Nevertheless, any suspicious structures may be pinched gently, and if facial twitching results, severely isolated.

The infiltrative type, with fibrous strands merging with gland tissue and muscle, has always presented the problem of possible facial paralysis when surgical excision is performed. This no doubt accounts for the incomplete removal and subsequent recurrence. On several occasions various authors have suggested that when the tumor is of this character a complete parotidectomy be performed (Bailey,<sup>6</sup> Patey<sup>7</sup>). However, this advice is not generally followed, possibly because of a misconception concerning the surgical anatomy of the parotid gland and the facial nerve. One point should be emphasized, namely, that the facial nerve does not pass within the actual substance of the gland, its main divisions lie between the deep and superficial lobes. However, because of the small size of the deep lobe, the outlying subdivisions of the nerve rest between the superficial lobe and the masseter muscle. The entire gland may be removed and the facial nerve remain uninjured if adequate exposure and careful dissection are employed.

To recapitulate, treatment consists of complete excision of the encapsulated type, with great care being taken to remove the capsule, and

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5 Ahlbom, H. E. *Acta radiol*, 1935, supp. 23, pp. 1-452

6 Bailey, H. *Brit J Surg* **28** 337-346 (Jan.) 1941

7 Patey, D. H. *Brit J Surg* **28** 29-38 (July) 1940

complete removal of the gland when the tumor is of the infiltrative type or variety

#### SUMMARY AND CONCLUSIONS

The mixed tumor is composed of complex embryonal cells of local origin which reproduce the normal development of the tissues and organs of the affected parts. The tumor may appear in any portion of the neck or the face, but in 50 per cent of the cases it occurs in the parotid gland.

The growth is slow, with periods of quiescence followed by activity.

Sixty-one cases are analyzed as to the site and the type of the tumor and as to recurrence.

The treatment, both proper and improper, is outlined.

403 Commonwealth Avenue

# Case Reports

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## PNEUMOCOCCIC MENINGITIS

### Presentation of a Case with Operation and Recovery

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AND  
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WE BELIEVE that the classification of cases of otitic meningitis presented by Kerrison<sup>1</sup> is the simplest, yet the most inclusive. He divided cases of otitic meningitis into those of circumscribed pachymeningitis and those of leptomeningitis.

Most aural surgeons have encountered circumscribed pachymeningitis accidentally during a mastoidectomy. The dura alone is inflamed and edematous, without the underlying structures being disturbed. The inflammation usually subsides promptly after removal of the surrounding necrotic bone. However, it undoubtedly is the precursor of more serious lesions.

The cases of leptomeningitis, which involves the pia and the arachnoid as well as the dura, were further subdivided by Kerrison into those of diffuse purulent, those of circumscribed purulent and those of serous leptomeningitis.

Diffuse purulent leptomeningitis is a suppurative inflammation of the meninges which has reached the subdural and subarachnoid spaces. The infection has spread widely, and there is no tendency on the part of the meninges to form limiting peripheral adhesions. Thus it is unavoidably accompanied by cortical encephalitis. Pus and bacteria are encountered in the spinal fluid, and, if one is to be certain of the diagnosis, the organisms must grow on culture.

Circumscribed purulent leptomeningitis is also a suppurative inflammation of dura, pia and arachnoid, but it is confined to a distinctly limited area by adhesions which bind the arachnoid and the pia to the dura and to the brain substance itself. However, there is never any assurance that the infection might not break its bounds and develop into the diffuse type or into an abscess involving either the temporal lobe of the cerebrum or the cerebellum.

Serous leptomeningitis also involves dura, pia and arachnoid, but no organisms can be found in the spinal fluid, although the meninges are congested and edematous.

There are a number of ways in which infection travels from the ear to the brain. The most common is by extending directly through the necrotic bone of the tegmen. Suppurative labyrinthitis may spread through the saccus endolymphaticus or through the aquaeductus cochleae and infect the meninges. Retrograde thrombophlebitis may involve

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Read before the Staff of St. Francis Hospital, Sept. 8, 1947.

<sup>1</sup> Kerrison, P. D. *Diseases of the Ear*, ed. 3, Philadelphia, J. B. Lippincott Company, 1923, pp. 382-393.

the meninges via the vessels that run from the mastoid process to the dura. Infection may also travel through the nerves leaving the internal auditory canal. According to Lederer,<sup>2</sup> the lymphogenous route is a possibility. He claimed that in severe streptococcic infections purulent material passes through the marrow spaces to the meninges.

The classic symptoms of meningitis are well known and need no further coverage here. However, Lederer described what is called a hood type of meningitis which may arise from otitic infection. In this condition, only the convexity of the brain is involved, thus there would be no nuchal rigidity and subsequently no Brudzinski, Kernig or Bondy signs.

#### REPORT OF CASE

*History*—Mr. H., a 47 year old white man, was brought to the hospital emergency room in a stuporous condition on April 14, 1947. His son provided the following information. There had been no previous history of ear trouble except that several years ago he refused to go swimming because of some vague ear complaint. Three days prior to admission he was seen by his family physician because of pain in his right ear. He was afebrile, and there was no discharge of the ear. Penicillin orally and heat in the form of a hot water bottle were prescribed. There was no progression of symptoms until the day of admission, when he complained of severe generalized headache, was feverish and vomited on several occasions. At approximately 1 p. m. he suddenly became stuporous and was again seen by his family physician, who promptly sent him to the hospital with a diagnosis of meningitis. On arrival at the emergency room he was delirious and restless and violently resisted examination. He would not respond to questioning.

*Physical Examination*—His temperature was 103 F., the right pulse rate was 88, the respirations were 24, deep and stertorous. The blood pressure was 150 systolic and 70 diastolic. His skin was hot, sweaty and flushed. Marked nuchal rigidity was present. There was a positive Kernig sign bilaterally. The Brudzinski sign was present. All extremities were flaccid, but passive motion was impeded. The reflexes were not exaggerated, and the Babinski sign was absent. Eyes, nose, chest and abdomen revealed nothing of note.

It was rather difficult to examine the ears because of the inability of the patient to cooperate. The left drum was intact, but was thick, dull and retracted and presented a large calcareous plaque in the anterior inferior quadrant. The right external auditory canal was filled with thick purulent material, which was definitely coming from the middle ear. There was a fulness in the attic area.

*Roentgen Findings*—The roentgen plates were not too satisfactory because of the inability of the patient to cooperate. However, they did show a tendency toward sclerosis on the right, with some pneumatization beneath a rather thick cortical plate. There was a fuzzy exaggeration of the cell walls. The findings were indicative of acute mastoiditis on the right side.

*Laboratory Findings*—A spinal tap was performed in the emergency room, followed by withdrawal of 8 cc. of turbid fluid, the supernatant layer of which was yellow. The initial pressure was 500 mm. of water, and the final pressure was 380 mm. There were 22,848 cells, 95 per cent of which were polymorphonuclear.

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2 Lederer, F. L. *Diseases of the Ear, Nose and Throat Principles and Practice of Otorhinolaryngology*, ed 2, Philadelphia, F. A. Davis Company, 1939, pp 191-193.

leukocytes and 5 per cent lymphocytes. The fluid was so filled with organisms that the laboratory was able to obtain type V pneumococci by direct Neufeld typing. Culture of a blood specimen taken at this time also revealed type V pneumococci, as did culture of the material from the right external auditory canal. The blood count showed 35,750 white blood cells of which 60 per cent were segmented cells and 35 per cent band cells of the granulocytic series, the remaining 5 per cent were lymphocytes. The subsequent laboratory work is summarized on chart 1.

**Treatment**—Because of the accumulated findings, it was decided to operate immediately. The patient was taken to the operating room under the influence of tribromoethanol solution U S P. Fifty thousand units of penicillin dissolved in 3 cc of sterile distilled water was administered intrathecally just prior to operation. Intravenous administration of  $37\frac{1}{2}$  grains (243 Gm) of sodium

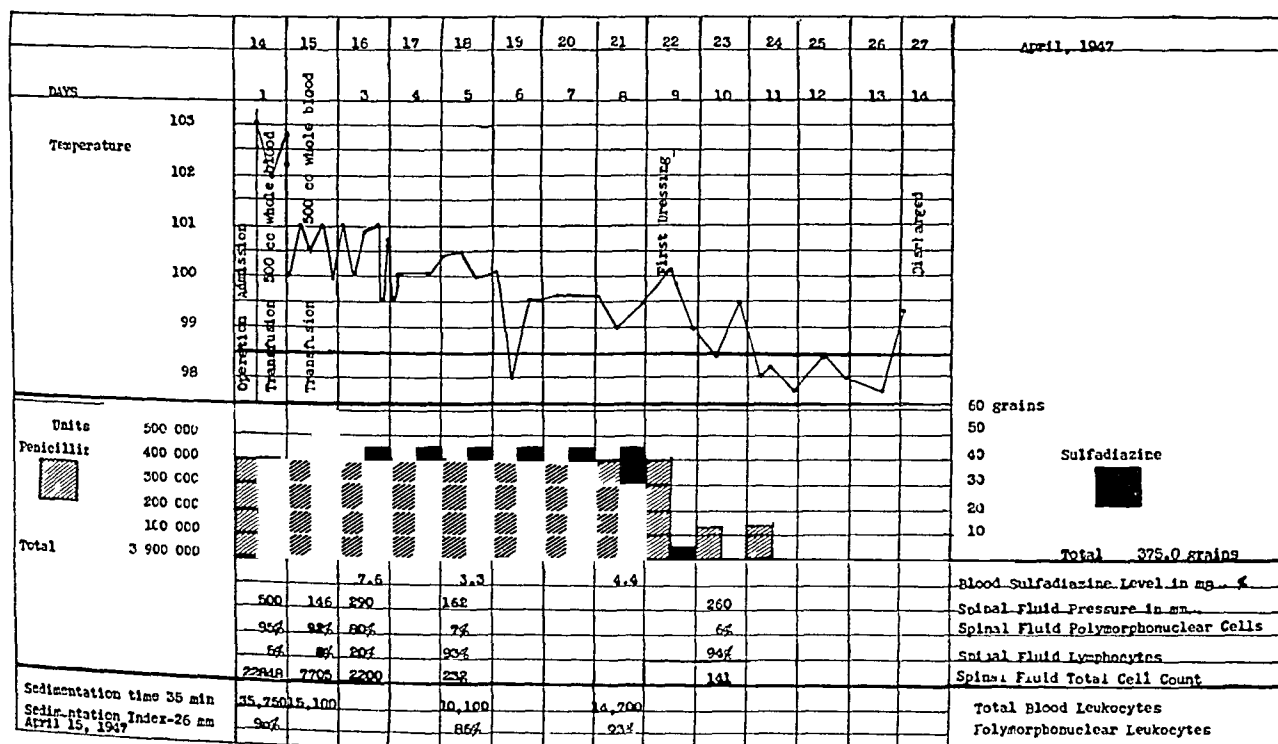


Chart 1—Clinical-therapeutic log of the patient

sulfadiazine and 300,000 units of penicillin dissolved in 1,000 cc of isotonic solution of sodium chloride was started. Ether anesthesia was administered approximately two and a half hours after admission. The type of operation to be performed presented no easy problem. It has been advocated that when operating on an acutely diseased ear one should perform the simple mastoidectomy, and when operating on a chronically diseased ear, the radical mastoidectomy. We were not certain whether the patient's condition was the result of acute otitis media or the result of acute exacerbation of chronic suppurative otitis media. It was decided that the safest procedure would be to perform a modified radical mastoidectomy of the Bondi type, in which the facial bridge is broken down but the pars tensa is preserved, so that if the patient recovered, a certain amount of hearing might be preserved. A postauricular incision was made. The cortex was found to be densely sclerotic and thick. Underneath, only diploic structures were

encountered. It was rather gratifying to find a large area of necrotic bone in the region of the mastoid tegmen. This was thoroughly removed and an area of dura approximately 2 cm in diameter was exposed. The dura was purplish and edematous but not tense. We could find no opening into the subdural space. We did not incise the dura. A Siebenmann flap was prepared, a split skin graft on a paraffin gauze mold was inserted into the cavity, the postauricular wound was closed completely with interrupted black silk sutures, and the cavity was drained with a loosely packed strip of iodoform gauze. The patient left the operating room in only fair condition.

The first postoperative day was rather a stormy one, however, by 8 p. m., thirty hours after admission, he was able to answer questions fairly intelligently. He was even able to take fluids by mouth. His restlessness was easily controlled by small doses of morphine. The temperature fell by lysis, and his progress was uneventful, with no tendency toward the relapse for which pneumococcic meningitis is well known. On April 27, after having completed thirteen days of hospitalization, he was discharged. At that time the postauricular wound was completely healed and there was only a small amount of material draining from the external canal. He was rather deaf, but his greatest complaint was an annoying tinnitus.

Office treatment was directed at simple cleansing of the cavity and catheterization of the eustachian tubes. An audiogram on May 12 showed an average decibel loss of 55 for the left ear and 80 for the right ear. On May 22 the loss was 50 decibels on the left and 65 decibels on the right. By August 4 the loss was 37 decibels on the left and 63 decibels on the right. At the time of writing the cavity is completely epithelized and dry. The left drum membrane, although somewhat thick, shows a fair cone of light and good luster. The Weber test sound is lateralized to the right. The Rinne test shows sound heard better by bone than by air conduction on the left and the reverse on the right. Tests showed hearing loss for all C forks in both ears. His only complaint is a rather annoying tinnitus, which is worse at night and during hot humid weather.

#### INTRATHECAL PENICILLIN THERAPY

The advisability of administering penicillin intrathecally was a problem in our minds because of the various reports in the literature of paralyzes developing from this therapy. Sweet and associates<sup>3</sup> reported 2 cases in which a neurogenic disturbance of the bladder developed which persisted for more than two weeks. Siegal<sup>4</sup> observed a patient in whom transverse myelopathy developed. Other workers have reported the development of paraplegia, convulsions and persistent headache.

Rammelkamp and Keefer<sup>5</sup> have shown that intrathecally injected penicillin diffuses throughout the ventriculosubarachnoid space and that significant amounts remain in the spinal fluid for twenty-four hours. They have also shown that even with a solution containing not more than 1,000 units per cubic centimeter intrathecal injection is usually fol-

3 Sweet, L. K., Dumoff-Stanley, E., Dowling, H. F., and Lepper, M. H. The Treatment of Pneumococcic Meningitis with Penicillin, *J. A. M. A.* **127** 263-267 (Feb. 3) 1945.

4 Siegal, S. Transverse Myelopathy Following Recovery from Pneumococcic Meningitis, *J. A. M. A.* **129** 547-550 (Oct. 20) 1945.

5 Rammelkamp, C. H., and Keefer, C. S. The Absorption, Excretion and Distribution of Penicillin, *J. Clin. Investigation* **22** 425-437 (May) 1943.

lowed by pleocytosis of a considerable degree (Note chart 1) Penicillin when given intravenously or intramuscularly does not get into the spinal fluid in any significant amounts. The pleocytosis that occurred in our case after a single injection of penicillin was marked

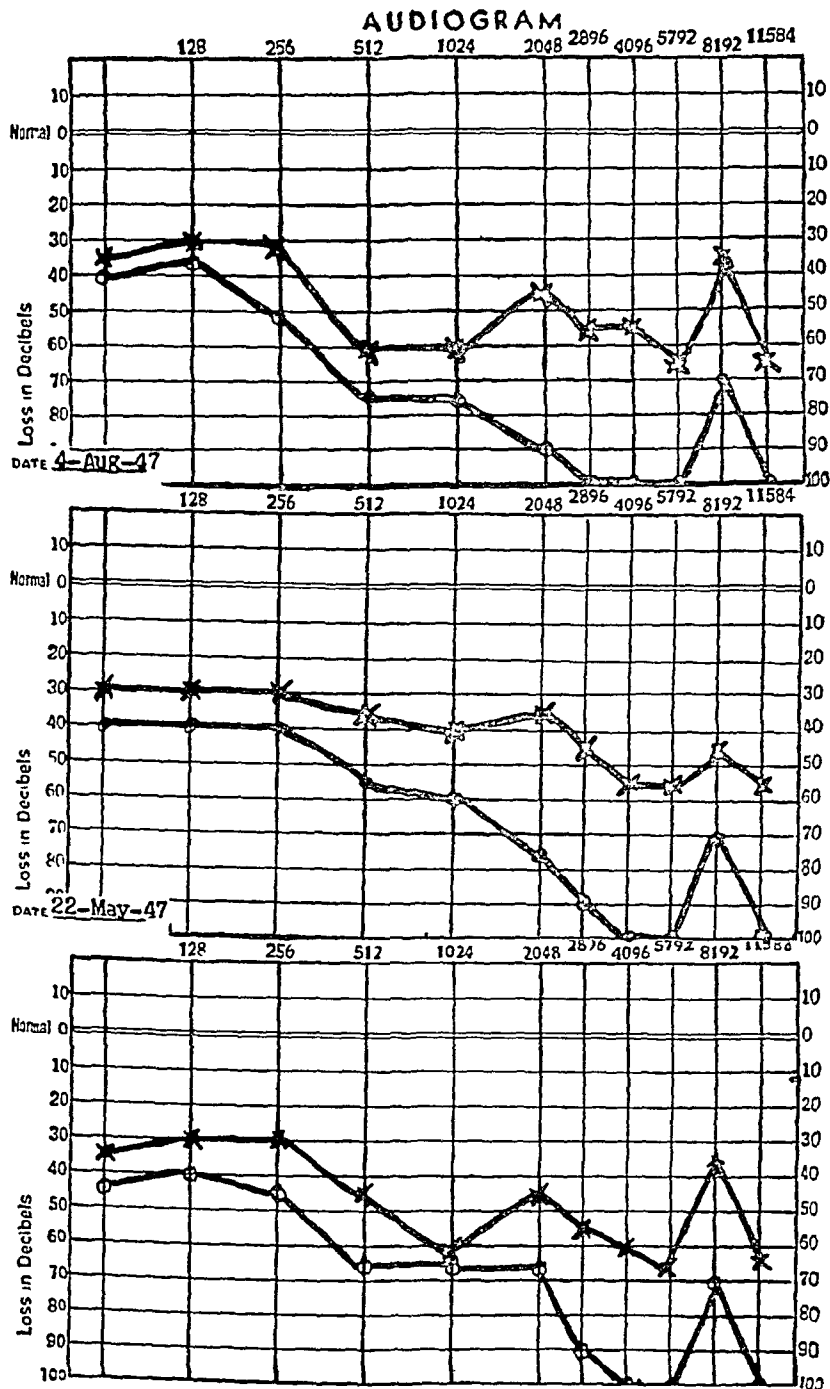


Chart 2—Postoperative audiometric findings

Multiple intrathecal injections of penicillin have been advocated in cases of pneumococcic meningitis. However, we decided on the single injection for three reasons. First, we were fearful of damaging the central nervous system, second, the clinical progress of our patient was



progressively for the better, and third we hoped that the large initial dose might be adequate to nullify the effects of the pneumococci present.

We feel that had it not been for the availability of sulfadiazine and penicillin along with proper surgical intervention, our patient certainly would have died.

#### SUMMARY

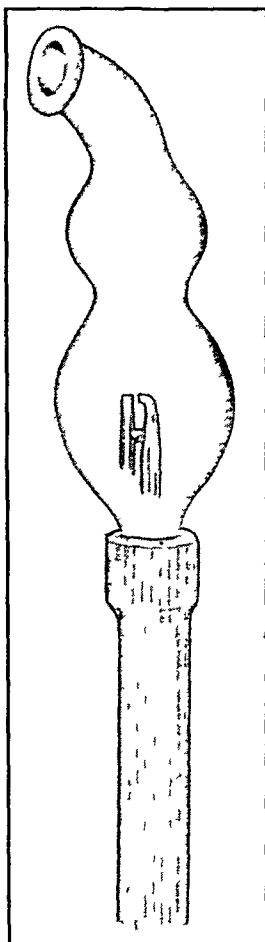
A case of type V pneumococcus otitic meningitis with operation and recovery is presented. A large concentrated single dose of penicillin was administered intrathecally with no resultant injury of the central nervous system. We feel that surgical intervention was as necessary to this patient's recovery as was the administration of penicillin and sulfadiazine.

# Clinical Notes; New Instruments and Technics

## SIMPLIFIED PENICILLIN NEBULIZER APPARATUS

MERVIN C MYERSON, M D  
BEVERLY HILLS, CALIF

MUCH has been written concerning aerosolizers for penicillin and other medicinal agents. All of the apparatus in use depend on the positive pressure of an oxygen tank to produce nebulization. In addition, a mask and a rubber bag are part of the equipment. The method which is the basis of this report depends



The simplified nebulizer. It is connected by the rubber tube with a source of compressed air.

on a small nebulizer which is connected by a rubber tube with a source of compressed air, either a tank or an electrically driven apparatus.

For some time I have been administering, in nebulized form, solutions of such substances as penicillin, streptomycin, sulfathiazole sodium, epinephrine hydrochloride, amphetamine and various antiseptic and oily mixtures for disease of the nasal and lower respiratory passages. When oil is used, sweet almond oil is

always the base. Oil is nebulized more rapidly than aqueous solution because of the greater viscosity, which offers more resistance to the stream of air, thereby causing greater diffusion.

When penicillin is used, 100,000 units is dissolved in 1 cc of distilled water. This solution together with 3 cc of sweet almond oil is introduced into the nebulizer. The agitation caused by the passage of the stream of air thoroughly admixes the aqueous solution and the oil. A visible mist is given forth when the compressed air passes through the nebulizer. The apparatus is then ready for use.

The nebulized medicament may be introduced directly into each nasal chamber by loosely inserting the open end of the nebulizer into the nostril. For treatment of the oral cavity or the pharynx, the open end of the nebulizer is held between the lips during quiet, effortless respiration. When the larynx, trachea or bronchi are to be treated the patient is instructed to inhale deeply.

The nebulizer requires no special space. Keeping it clean presents no problem. The flow of compressed air is controlled by a simple valve, so that the patient may discontinue treatment at will.

It is hardly necessary to mention the extreme simplicity of this form of treatment. It has a special appeal to children. The oxygen aerosolizing apparatus is cumbersome, space consuming and not without discomfort to the patient. Many children object to it. All of these objections are overcome when this simple nebulizer<sup>1</sup> is used.

416 North Bedford Drive

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<sup>1</sup> This nebulizer is made by Parke, Davis & Company, for epinephrine inhalation.

## OTOSCLEROSIS

### An Index of the Literature, with Abstracts, for 1947

THIS is the fourth instalment of volume IV "Otosclerosis" to be issued by the Central Bureau of Research of the American Otological Society, Inc.<sup>1</sup> We have been able to obtain and abstract several heretofore unavailable articles in foreign literature. Included among the abstracts are some on correlated subjects investigation of which is encouraged by the Bureau.

As in previous instalments, the opinions of the authors are quoted without comment, and the selection of articles implies no endorsement or condemnation thereof. The titles are given in English and the names of the mediums of publication in the language of the original. Dr Franz Altmann has continued to cooperate in the preparation and translations of the abstracts. Owing to the labor difficulties, this instalment has again been unavoidably delayed. We trust that it will be possible to publish the abstracts of the 1948 literature before the end of 1949.

The preponderance of articles on the fenestration operation continues. Although there is much repetition, we have endeavored to present fully all of the points of view. A reprint of this instalment, with index of authors according to subjects and perforated for loose-leaf binding in volume IV "Otosclerosis," may be obtained at cost (\$1.00) from

EDMUND PRINCE FOWLER, M D, *Editor*

140 East Fifty-Fourth Street, New York 22

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<sup>1</sup> The Central Bureau of Research (originally the Committee on Otosclerosis) of the American Otological Society, Inc, is constituted as follows: Board of Trustees of the Research Fund: D. Harold Walker, M D, chairman, Boston; John R. Page, M D, vice chairman, New York; Edmund Prince Fowler, M D, secretary, New York; Wesley C. Bowers, M D, New York; Marvin F. Jones, M D, New York; J. Gordon Wilson, M D, Chicago; D. E. Staunton Wishart, M D, Toronto, Canada. Lay Advisers to the Board: E. Ericson, New York; Samuel Lloyd, New York. Consultants to the board: Madison Bentley, Ph D, LL D, professor of psychology emeritus, Cornell University; J. B. Collip, M D, D SC, F R C P, F R S, professor of medical research, University of Western Ontario; Stacy R. Guild, Ph D, Johns Hopkins; Oscar Riddle, Ph D, LL D, D H C, Plant City, Fla.; Philip E. Smith, Ph D, professor of anatomy, College of Physicians and Surgeons, Columbia University. Treasurer: Walter C. Baker. Depositary: Guaranty Trust Company of New York. Office of the Secretary: 140 East Fifty-Fourth Street, New York 22.

**de Amicis, E** The Regeneration of Bone Tissue After Experimental Injury of the Labyrinthine Capsule in Dogs, *Pract oto-rhino-laryng* 9: 295, 1947

The material which brings about the repair of experimental injuries of the labyrinth in dogs consists of bone and connective tissue. In this reparation the periosteum of the endocranium takes a greater part than the periosteum of the middle ear. The endosteum of the cavities of the labyrinth responds vigorously to trauma by filling the defects with newly formed bone. Besides the periosteum and the endosteum, osteoblasts which originate from the vascular channels in the bone take part in closing gaps in the capsule. Narrow fissures are filled for long distances with osteoid tissue formed by these osteoblasts. Where the latter are absent, the fissures are closed by connective tissue only or remain patent. Fissures in the region of the promontory lead to a free communication between the tympanic cavity and the inner ear spaces.

**Aubry, M** The Surgery of Deafness, *Ann d'oto-laryng* 13: 29, 1946

The author reviews the history of the operation designed to aid the patient with otosclerosis. He mentions the fact that the shifting of the fistula toward the ampulla may lead to prolonged vestibular disturbances. The author has recently followed Lempert's fenestra nov-ovalis technic, but he used the mobile acrylic stopple instead of cartilage. He feels that a final technic has not yet been developed.

An advantage of the operation over the use of a hearing aid is in the fact that "the progress of the deafness can be checked by the operation."

The author operates on patients who have a rapidly progressive impairment of hearing with well preserved function of the inner ear as determined by the bone conduction of frequencies 2048 and 4096. For other patients a hearing aid seems preferable.

**Aubry, M** Preoperative Audiometry. Evaluation on the Operating Table of the Primary Gain in the Course of Fenestration, *Ann d'oto-laryng* 64: 642, 1947

The operations were performed with the patients under local anesthesia, and five audiometric curves were taken as follows:

1. On the operating table before surgical intervention had taken place. This curve is often not as good as the preoperative curves, owing to the effect of the preoperative sedation.

2. At the time when the "blue line" becomes visible. The curve is not different from curve 1.

3. When a fine opening into the membranous endosteum has been made.

4 When the fenestra has acquired its final shape Curves 3 and 4 are almost identical As soon as the perilymphatic space is opened, the maximum primary gain is obtained, regardless of the size of the opening The average gain for the frequencies up to and including 1024 was 16.3 decibels, above 1024 it was 6.3 decibels

5 The flap placed over the fistula caused only a slight reduction of hearing

For practical purposes it is sufficient to take curves 1 and 4

Curves taken one to two months after the operation showed a secondary gain of 5 to 10 decibels for the various frequencies The bone conduction did not vary significantly in the 18 cases examined

Aubry, M Surgery of Deafness, *Ann d'oto-laryng* 4.5, 1947

The author reviews the history of the operation for deafness caused by otosclerosis and describes Sourdille's and Lempert's technics

Aubry himself uses the endaural approach without excision of the triangular piece of skin He performs atticotomy simply by enlarging the canal toward the roof without opening the antrum or the aditus The incus is removed, and the flap is formed in such a way that it covers the entire internal attic wall and closes the opening to the antrum In this way the bony reformation is reduced to a minimum, the mastoid process is excluded from the postoperative reaction, the postoperative labyrinthitis is prevented to a large extent and the time of operation is reduced

The ideal fenestra should have the following properties It should be large This is achieved by making it in the ampulla of the lateral canal (what Lempert calls the dome of the vestibule) This position of the fistula does not cause prolonged dizziness except in a very small number of cases The margins of the fenestra should be carefully thinned out and enchondralized, a procedure that also facilitates the adherence of the membranous labyrinth to the under surface of the flap which prevents interposition of bone The endosteum should be completely removed with the help of magnifying glasses Constant irrigation is useful The flap should be made as thin as possible

The author thinks that a successful Sourdille operation with preservation of a mobile incus should theoretically give a better result than a Lempert operation With Sourdille's technic, however, a perfect result is more difficult to obtain

In discussing the results of operation he feels that the statements of the authors who report success in about 90 per cent of the cases are too optimistic He discusses the two methods of computing the results (1) that of determining the average decibel gain and (2) that of determining whether the conversational level has been reached or not

He discusses the various causes of failure. He then reports 2 cases in which the bone conduction was poor and the operation produced only a negligible improvement in hearing but was followed, in one of the cases, by disappearance of the noises, also, 2 cases in which the bone conduction was good. In another case a rupture of the drum membrane had occurred and the hammer had to be removed together with the anterior portion of the drum. The fenestra and the tympanic defect were covered with a Thiersch graft, which took, and the operation was successful.

In still another case, in which fenestration was done ten years ago, the hearing had not noticeably improved, but neither had it become worse, whereas there was a deterioration in the other ear, not operated on. He has observed 2 similar cases and feels that in these cases, in spite of secondary closure of the fistula, the otosclerotic process was arrested by the operation.

The author operates on all patients with good bone conduction whose loss of air conduction approaches or exceeds the minimum level of 30 decibels. The preoperative loss for bone conduction must not exceed 35 decibels. The operation is particularly indicated in cases of rapidly progressing impairment, no matter what the loss by air conduction, provided the bone conduction loss is not too excessive. The more affected ear should be operated on first, later, if the improvement has been maintained for at least eight months, the other side may be operated on.

The respective advantages and disadvantages of hearing aids and operations are discussed. The most important argument in favor of operation is the statement that the operation "seems to arrest or at least to retard the progress of the disease."

Aubry, M. The Surgical Treatment of Deafness. A Simplified Fenestration Technique, *Presse méd* 55. 237, 1947

The technic consists in the following steps:

Only two endaural incisions are made, and the triangular piece of skin is not excised. The skin of the superior and posterosuperior circumference of the osseous external meatus is separated from the bone right up to the drum. Atticotomy is performed, and the malleus and the incus are thoroughly exposed. This is followed by removal of the incus and the head of the malleus. The fenestra is then made into the ampulla of the horizontal canal under continuous suction and irrigation. The flap is made from the detached skin of the meatus and reflected over the fistula and the medial wall of the attic. The flap covers the aditus and antrum and separates the mastoid process from the operative cavity.

The author's method results in a small operative cavity with considerably lessened danger of postoperative infection and discharge

von Békésy, G. The Sound Pressure Difference Between the Round and the Oval Window and the Artificial Window of Labyrinthine Fenestration, *Acta oto-laryng* 35 (no 3): 301, 1947

The author's summary is quoted

Based on the principle of reciprocity a new method has been developed which permits the determination of quite small differences of sound pressure both as to magnitude and phase. By this method the differences of the sound pressure between the round and oval windows has been determined in human ear preparations lacking the middle ear apparatus. The pressure difference is so small that it can have no importance for the hearing of patients with missing middle ear apparatus. The established view that the round window is protected against the sound pressure in consequence of its place in a niche, is untenable.

However, in several preparations the differential sound pressure between the round window and an artificial opening at the ampulla of the horizontal semicircular canal is of the same order of magnitude as the sound pressure in the auditory canal. In this way a total hearing loss of only about 30 db arises as against the normal ear. Thus, in these cases a window at the semicircular canal would have been a fair substitute for a functioning middle ear apparatus.

By studying a model it is shown that the pneumatic cells of the mastoid process act as a resonance chamber in the mouth of which the artificial window is situated. This explains why a large sound pressure difference is found between the round and the artificial window, often in the whole hearing range above 500 c/s.

The possible clinical importance is mentioned of increasing this resonance chamber in labyrinthine fenestration operations.

Bonham, W. L. The Surgery of Deafness Due to Otosclerosis, *J Oklahoma M A* 40: 41, 1947

This is a review of the problem for general practitioners

Brickley, D. W. Otosclerosis and Blue Scleras, *Arch Otolaryng* 46: 230 (Aug) 1947

This is a report of 2 cases illustrating the factor of dominant heredity. In one the transmission was through the male side, and in the other, through the female side. In the first case the deafness was initially manifested at the age of 19 years. It progressed rather rapidly, with the cochlear organ becoming involved in the relatively short time of three years. In the second case, the deafness was noted at the age of 29 years, and there was no nerve involvement after two years.

Brunner, H., and Cutler, M. H. Labyrinthine Symptoms Subsequent to Fenestration of the Labyrinth, *Arch Otolaryng* 45: 613 (June) 1947

The authors studied the symptoms and came to the following conclusions



Twenty-four hours after fenestration of the labyrinth there is horizontal and rotatory nystagmus of the third degree to the side of the fenestration, the nystagmus disappears in three to four days. After surgical injury of the horizontal semicircular canal there is horizontal and rotatory nystagmus of the third degree to the other side, persisting for two to four weeks. This difference is caused by the infection which is always associated with surgical injuries. Such infection is usually absent in fenestration. When the patient looks straight ahead twenty-four hours after the operation there are frequently slow oscillatory movements of the eyes, synchronous with the pulse. Occasionally there is "nystagmus of the head."

If, after fenestration, the nystagmus is directed toward the side of the fenestration and decreases in a period of a few days, it is caused by the opening of the perilymphatic space. If, however, the nystagmus is directed toward the other side, or if it continues for more than one week, an infection of the fenestra is likely to have occurred.

The slow oscillatory movements of the eyes and the "nystagmus of the head" do not indicate an infection of the fenestra.

Pressure applied over the fenestra with cotton on an applicator yields a positive response more frequently than does the pneumatic pressure obtained with a Politzer bag.

There are cases in which probing of the fistula produces the fistula symptom, while compressing the air of the canal with the Politzer bag does not produce it.

After fenestration of the labyrinth the fistula test should be performed with the Politzer bag and not with the cotton applicator. The point at which the fistula is located in the horizontal semicircular canal does not influence the results of the fistula test.

Atypical responses to the fistula test do not necessarily mean inflammation of the perilymphatic space.

**Carruthers, D. G.** Surgical Technic of Operation of Labyrinthine Fenestration for Oto-Sclerotic Deafness, *Australian & New Zealand J. Surg.* 17. 37, 1947.

The author finds local anesthesia highly satisfactory. He recommends a solution of epinephrine hydrochloride, 1:75,000. He describes the method of infiltration used by him. Under general anesthesia, there is at times a greater tendency to bleed. Lempert's endaural incision is adequate, but the regular mastoidectomy incision provides an almost equally good exposure, provided it is extended sufficiently forward at its upper extremity. With the posterior approach it is wise to make an incision in the skin of the external meatus to delineate the outer

end of the epidermal flap and to avoid tension on the part of the retractors, which may cause tearing of the lining in its more delicate inner part where it joins the tympanic membrane

In the actual operation he follows Lempert's fenestra nov-ovalis technic with stopple. He thinks, however, that Shrapnell's membrane can never be made to cover the fistula, even when the latter is made far forward. The site of the fistula, in the fenestra nov-ovalis technic, is not in the position Lempert assumes it to be, on the surgical dome of the vestibule. It is over the anterior extremity of the external semicircular canal.

Postoperative vertigo never caused severe distress in any of the author's cases. There was a discharge from the wound for six to eight weeks, and sometimes an acute infection of the middle ear occurred at about the twelfth postoperative day, which persisted for three to eight weeks. The epithelization cannot be speeded up by the use of chemotherapy.

The author recommends that there be daily sterile dressings for at least four weeks.

**Cawthorne, T** Otosclerosis, *Practitioner* 158 109, 1947

This is a review of the pathology, symptomatology and therapeutics of otosclerosis for the general practitioner.

**Cawthorne, T** Review of Surgery of Otosclerosis, *Proc Roy Soc Med* 40 320, 1947

The author reviews the history of the surgical treatment of otosclerosis and then describes his own experiences.

He uses a Leitz dissecting microscope which gives 10 diameters of magnification and a working distance of 22 cm.

He thinks that any patient presenting uncomplicated otosclerosis is suitable for operation—that is, if the loss of hearing for the three crucial speech frequencies is not greater than 55 decibels. Lesions of the internal ear should be absent. Their presence is suggested by an alteration in the timbre of the patient's voice, intolerance of amplification, disappearance of paracusis and loss of acuity for bone conduction. However, the results obtained when bone conduction receivers are employed are not as accurate as those obtained with air conduction.

The author feels that with favorable conditions there is a 50 per cent chance of a substantial improvement of hearing that may be maintained for several years. In 5 per cent of the cases the hearing of the ear operated on may be much worse and may frequently disappear entirely.

Croushore, J E The Fenestration Operation for Otosclerosis, *Harper Hosp Bull* 5 128, 1947

The author briefly reviews the problem

Day, K M Medical and Surgical Care of the Patient Selected for Fenestration of the Labyrinth, *Arch Otolaryng* 46 534 (Oct), 1947

There are three primary causes of failure of the fenestration operation

- 1 Faulty diagnosis and selection of cases Cases may be included in which a perfectly performed operation will not restore practical hearing

- 2 Fibrosis of the vestibule, resulting from hemorrhage, entrance of foreign material or damage of the vestibular contents

- 3 Closure of the fenestra

The faults which cause bony closure lie, in the author's opinion, mainly in the operator A clean fenestra covered by a clean and healthy flap will not close in the absence of stimulative inflammatory reactions

The patient should be in good physical condition and free from active nasal allergies A patient whose psychologic stability is in doubt should be examined by a psychiatrist If local anesthesia is employed, an explanation should be given to the patient concerning what he may expect to experience during and after the operation If one of the barbiturates is used for intravenous injection, one should make sure that the patient is not allergic to barbiturates Liberal intake of fluid is encouraged up to within two hours of operation

During the preparation of the operative field, it is well to prevent mercurial or iodine solutions from entering the external meatus, occasionally the skin may prove sensitive to such solutions Filling the external meatus with 70 per cent alcohol for ten minutes and then closing it with sterile cotton has proved to be adequate for antisepsis

The packing should not be too tight, it should be nonirritative, non-adhesive and nonobstructive Paraffin gauze is satisfactory in these respects The packing can be removed on the fifth day After that, for the next few weeks local treatment is usually limited to cleansing the external meatus and mopping out excessive secretion

The patients should be encouraged to sit up on the day of operation and to get out of bed on the next day Normal stimulation seems to hasten rather than retard the adjustment These patients show less reduction of hearing for the high frequencies after three to four weeks than those who were confined to bed for several days after the operation

The postoperative care of the cavity is often a real problem. Too many patients who are discharged before healing is completed acquire secondary infections which persist indefinitely. Both the operation itself and the after-care of the cavity are individualized problems which often test the surgeon's knowledge, judgment and ability.

**Editorial.** Surgery for Deafness, *Lancet* 252. 181, 1947

This is a general review of the problem

**Editorial** Surgical Treatment of Deafness, *An med*, Barcelona 22: 194, 1947

**Ersner, M S, and Saltzman, M** Speech Hearing in Otosclerosis, *Arch Otolaryng* 46:753 (Dec ) 1947

A characteristic response to tests for hearing of words was noted in patients with otosclerosis. There is greater loss for speech than for the frequencies most used in speech. There is a more marked loss for the words of the low frequency range. The air conduction audiograms of 3 different patients may show equal degrees of pure tone deafness, but the word tests may reveal differences. This difference aids in making a differential diagnosis between otosclerosis, nerve deafness and adhesive otitis media. The test words used are grouped into two lists. Common words of the lower frequency range constitute one, words of the higher frequency range, the other.

In otosclerosis the loss of hearing for words, particularly for words of the lower frequency range, is greater than the loss of hearing determined from the pure tone audiogram according to the Fowler-Sabin method of the American Medical Association.

In perceptive deafness the loss of hearing for words is less than the percentage loss of hearing for pure tones.

In adhesive deafness the word-hearing loss is still smaller.

In the differential diagnosis of the causes of deafness the patient's tolerance of, and benefit from, sound amplification are important.

In cases of otosclerosis microphone amplification offers an easy means of determining whether or not the patient is suitable for the fenestration operation.

**Farrior, J B** The Fenestration Operation for Deafness, *J M Alabama* 16. 317, 1947

This is a review of the problem for the general practitioner.

**Fishman, L Z** Lempert Fenestration Preliminary Report on Fifteen Cases, *Bull Pract Ophth* 16: 11, 1946

**Fishman, L Z, and Fishman, V P** Tinnitus Aurium (Including Report of Results Following Lempert Fenestration and Tympanosympathectomy), *ibid* 16 44, 1946

Thirty-five fenestrations are tabulated for comparative study Among these, many cases of so-called nerve deafness and of clinical otosclerosis are reported in which tinnitus was relieved completely or to a considerable extent by decompression of the labyrinth, irrespective of the degree of improvement obtained in the hearing, in some cases in which there was no improvement of hearing, tinnitus was, nevertheless, relieved

Of 5 cases in which a Lempert sympathectomy was performed, the results were successful in 2

**Flagg, P J** The Fenestration Operation Major Hazard, The Anesthetic, editorial, *Am J Surg* 72:497, 1946

the popularization of massive sedation as a substitute for general anesthesia in the fenestration operation endangers the life of the patient and prolongs the operative procedure Bleeding in the field occurs from venous ooze and from arterial blood Venous ooze is increased in respiratory obstruction and during spasm or straining from periosteal pain in which massive sedation is used Sedation (barbiturates up to 9 gr and morphine  $\frac{1}{2}$  gr) requires prolonged and careful postoperative nursing to prevent asphyxial accidents Safety is assured and venous oozing is eliminated by a properly conducted general anesthesia with ether carried on by the endotracheal inhalation technic without carbon dioxide absorption Well selected, small doses of preoperative and postoperative medication provide comfort for the patient The employment of this technic will prevent asphyxial deaths

The author is against the use of intravenous pentothal sodium® He mentions a patient who received 2.5 Gm of pentothal sodium® over a period of one hour and forty minutes and was unconscious for three days The temperature rose to 104 F postoperatively The patient was restless and respirations were depressed until recovery

**Fowler, E P** Otosclerosis in Identical Twins Five Case Histories, *Ann Otol, Rhin & Laryng* 56 368, 1947

The author discusses his studies of identical twins and in particular pertinent agreements and differences observed in five pairs of identical twins, all the members of which with the exception of one twin had otosclerosis Detailed audiograms show the variations of hearing over several years In every instance the twins were nursed or fed similarly and lived closely together, their finger prints and photographs were remarkably similar Detailed personal, family and otologic histories and the results of laboratory examinations are given The data are interesting, and much of the information is suggestive of cause and treatment The following observations were discussed

- 1 The mother's milk was deficient in every instance
- 2 In the 8 females menstruation began earlier in the twin who is now the deafer in each pair
- 3 Medication containing fluorine and a dietary intake of calcium and phosphorus were prescribed for at least one twin of each pair
- 4 During several years little if any increase of deafness has been noted in these twins in spite of some childbirths and infections of the upper respiratory tract in several instances
- 5 With the exception of one twin (twin A, fourth pair) the deafness was shared by both twins in each pair and by both ears of both twins in each pair. This is interpreted as indicating that either the hereditary or the environmental factors or both must have had similar etiologic effects in the two twins of every pair but one. In this pair only one twin had deafness, blue scleras and a noticeably nervous disposition. The other twin had normal hearing, white scleras and no noticeable nervous symptoms. This exceptional pair of twins will be followed with interest in the years to come.

Fowler, E. P. Otosclerosis, Progressive Deafness and Correlated Problems, *Hearing News* 15: 5, 1947

Excerpts are printed from the *Rhode Island Medical Journal* (30: 105, 1947)

Fowler, E. P. Otosclerosis, Progressive Deafness and Correlated Problems. What Has Research Discovered and What Does the Future Promise? *Rhode Island M J* 30: 105, 1947

This is a review of the subject presented at the meeting of the Eastern Section of the American Hearing Society in Providence, R. I., in 1946

Fumagallo, P. L. The Surgery of Otosclerosis, *Arch mex* 5: 378, 1947

Godsall, R. S. Surgical Treatment of Deafness. The Fenestration Operation for Otosclerosis, *M J Australia* 1: 62, 1947

Godsall writes a letter to the editor of the *Medical Journal of Australia* condemning the "parish pump" outlook expressed in an article which he had read in the journal and which he believed to be at variance with current Australian medical and surgical thought. He states

With regard to the fenestration operation, there is no doubt that Lempert is a past master in this particular procedure, of which he has done several thousands. Holmgren of Sweden, who is looked on as the originator of this operation and has practiced it for three decades, remarked, after watching Lempert work, that he had learned more in that morning than in thirty years of his own work.

**Glynn, R M** The Lempert Operation, *M J Australia* 1.796, 1947  
The problem is reviewed

**Gorelik, B** The Surgery of Otosclerosis in U S A , *Ann d'oto-laryng* 64: 659, 1947

This is a general review and report of the transactions of the Annual Meeting of the American Medical Association held in Atlantic City, June 13 to 17, 1947

**Guns, P** The Problems of Deafness Operation or Prosthesis, *Rev méd de Louvain* 5.73, 1947

(This article is not available )

**Hall, I S** Four Cases Illustrating Results in the Treatment of Otosclerosis by the Fenestration Operation, *J Laryng & Otol* 61 644, 1946

This is a report of cases

**Hamberger, C-A , and Nydén, H** Cytochemical Studies on Experimental Bone Fistulae A Contribution to Research in Otosclerosis, *Acta oto-laryng* 35 479, 1947

The authors' summary follows

Bone formation in 200 experimental fistulae on the synciput of guinea-pigs has been studied by means of cytological and cytochemical methods Anti-mitotics, colchicine and sodium cacodylate, have been used in an attempt to prevent the first phase of bone regeneration—the differentiation of the osteoblasts These are characterized cytochemically in the normal course by the distinguishing features of cells with a considerable protein production The occurrence of polynucleotides in high concentrations in the cytoplasm can be demonstrated and a well-developed nucleolar apparatus is found in the nucleus

It appears highly probable that the osteoblasts actively contribute to the production of osteogenic tissue rich in proteins Anti-mitotics delay and disorganize the development of osteoblasts by injuring the nuclear apparatus The bone regeneration of fistulae is thereby delayed to approximately double the time, but is not prevented

**Harris, H E** The Fenestration Operation in the Treatment of Deafness, *Ohio State M J* 43 741, 1947

The problem is reviewed for practitioners

**Harris, H E , and Hale, D E** Induced Hypotension in the Control of Bleeding During the Fenestration Operation, *Tr Am Acad Ophth* 52.90, 1947

In order to avoid troublesome bleeding which occurs during the fenestration operation, in about 30 per cent of the cases, the following

procedure was used in 37 patients. Blood was withdrawn from the radial artery until the blood pressure fell to a level at which the operative bleeding was controlled. The blood was returned by the same route at the conclusion of the operation. The blood was withdrawn only at the time the effect was needed and was returned as soon as the need was past.

Blood was withdrawn until the systolic pressure had fallen to a level of 80 and was kept in flasks with a capacity of 500 cc of blood and 50 cc of a 4 per cent solution of sodium citrate. Usually about 1,800 cc was withdrawn, but many patients did not receive back the last 500 cc withdrawn. The resulting mild dehydration apparently reduced the local preoperative edema and lessened the vertigo, nausea and headache.

The procedure is not advocated for all patients, but only for those who show a tendency to bleed. If carried out under proper precautions it appears to be a valuable adjunct to fenestration surgery.

**Discussion** W. M. Cole, Chicago, fears the method might produce serious cerebral anemia because the blood pressure might fall below 70 mm of mercury. If the pressure stays below 70 for more than a few minutes, it is almost certain to be harmful.

H. House, Los Angeles, feels that troublesome bleeding has not been a major problem in fenestration surgery and that it can always be controlled by conservative methods patiently applied. He thinks that the suggested method is potentially dangerous.

**Hennebert, P. E.** The Audiogram in Otosclerosis, *Acta oto-rhino-laryng. belg.* 1: 339, 1947.

The author found in audiograms of patients with otosclerosis and frequently in those of patients with lesions of the superior centers a "negative dip," i.e., an important conservation of hearing in a circumscript area, while at other frequencies a general loss of hearing was present. For patients with otosclerosis such a negative dip should be common experience. Its localization is mostly at 2048 or 4096. At this point the threshold may rise from 15 to 20 decibels above that for the neighboring frequencies.

**Henschel, C.** The Surgery of Deafness. Method of Fenestration, *Rev. méd. Liège* 2: 575, 1947.

The problem is reviewed for the general practitioner.

**Hershey, S. G., and Jones, M. J.** Anesthesia for the Surgical Correction of Deafness, *Arch. Otolaryng.* 46: 390 (Sept.) 1947.

The authors discuss the surgical and anesthetic problems involved in the fenestration operation, and a tentative anesthetic regimen is presented in relation to these problems.



It consists of the following steps

- 1 Premedication with pentobarbital sodium, morphine and scopolamine hydrobromide
- 2 Production of basal narcosis through rectal instillation of a tribromoethanol solution
- 3 Induction of anesthesia by inhalation of nitrous oxide
- 4 Insertion of both an oropharyngeal and a nasopharyngeal airway

Hicguet, G, and Van Eyck, M Thoughts and Observations About the Surgery of Deafness, *Ann d'oto-laryng* 64 634, 1947

The authors make two incisions, similar to Lempert's first and second incision, and use a special retractor In order to facilitate the thinning out of the skin of the meatus, a glass tube is introduced into the latter An incomplete mastoidectomy is performed, and continuous irrigation is used while the fistula is being made The operative cavity is filled with pieces of rubber sponge

The authors noticed horizontal nystagmus to the side operated on when in the course of the operation the "blue line" became visible The nystagmus did not change while the endosteum was exposed However, as soon as the perilymphatic space was opened and perilymph escaped, the nystagmus changed its direction to the opposite side It gradually subsided within two to three days, it is probably due to a disturbance of the equilibrium between endolymph and perilymph

For the prevention of postoperative serous labyrinthitis, the authors recommend that 5 cc of a 50 per cent magnesium sulfate solution or 10 cc of a 10 per cent sodium chloride solution be injected intravenously every three hours for four days

Sometimes considerable improvement in hearing was noted in the ear not operated on Among the patients whose hearing was permanently improved, the fistula sign had completely or almost completely disappeared in all except 1

Hicguet, E G The Surgery of Deafness, *Bruxelles med* 27 71, 1947

A case of unilateral otosclerosis in which the fenestration operation was performed is reported

Holmgren, G Otosclerosis Surgery, *Pract oto-rhino-laryng* 8 441, 1946

The author discusses in detail the history of the operative treatment of otosclerosis He stresses the difficulties of the clinical diagnosis of the disease and reports 42 cases He used Lempert's fenestra nov-ovalis technic without stopple, with the endaural approach The criteria for operation were less strict than those recommended by Lempert Patients

with a hearing loss for bone conduction up to 50 to 55 decibels were included. In 1 patient with a bone conduction loss of 45 decibels for 1024 and 40 decibels for 2048 the result was excellent, not long enough time has elapsed since the operation to permit a final opinion. He nevertheless feels that the operative treatment gives excellent results. The question of indication is still unsettled and the technic still difficult. He reports his attempts at simplification, carried out on the cadaver.

He discusses the fact that in many patients the hearing on the side not operated on improves immediately after the operation. The improvement can be demonstrated by air and bone conduction. He does not know how long this improvement will last and is unable to explain it.

**Holmgren, G** Surgical Treatment of Otosclerosis, *Časop lék česk* 86. 815, 1947

After a historical survey of the evolution of the fenestration method, the author reports his own experiences and describes the details of various methods used in the United States. He believes that the operation and the postoperative care should be simplified and shortened by limiting the extent of the preparation to the lateral attic wall.

**House, H P** Indications for the Fenestration Operation, *Arch Otolaryng* 45 312 (March) 1947

The author analyzes 111 cases in which patients were operated on by the Lempert fenestra nov-ovalis technic. Candidates for the operation may be classified as ideal, borderline and unsuitable, depending on the amount of nerve function present in response to the speech frequencies. This is determined with tuning fork and audiometer. If the patient with clinical otosclerosis has a loss of serviceable hearing, the result of the Rinne test made with a 1024 fork is negative in direct proportion to the difference between air conduction and the degree of cochlear nerve function present.

**Ideal Candidates** The von Mueller magnesium alloy 1024 tuning fork is heard ten seconds or longer by bone conduction than by air conduction. The nerve loss by audiometry is 10 decibels or less for the speech frequencies. Among 49 patients operated on, 39 or 79 per cent, have retained serviceable hearing for longer than six months. The fistula closed in 4.

**Borderline Candidates** The 1024 fork is heard five to ten seconds longer by bone than by air conduction. The nerve loss by audiometry does not exceed 20 decibels for two speech frequencies, 512 and 1024, and is not more than 30 decibels down for the remaining most important frequency, 2048. Of 62 patients operated on, 34, or 55 per cent, have maintained serviceable hearing for more than six months. Closure of the fistula occurred in 8.

**Candidates Not Suitable** The 1024 fork is heard longer by air conduction than by bone conduction. The nerve loss as shown by audiometry is more than 20 decibels for two speech frequencies, 512 and 1024 or more than 30 decibels for the remaining most important frequency, 2048.

Occasionally, the operation may be performed on a patient whose nerve function is shown by tuning fork and audiometer to be just below the lower limit for the borderline group. For a young patient who is encountering a rapid loss of nerve function "the operation may be justified as an attempt to prevent further loss of nerve function as well as to improve the hearing." Likewise a patient with otosclerosis whose nerve function is just below the lower limit for the borderline group and who is suffering from considerable tinnitus may at times be benefited by fenestration. Of 6 patients operated on, 2 obtained a practical hearing level. In one there was no audiometric improvement but the tinnitus was eliminated in the surgically treated ear. This has allowed the patient to use his hearing aid with greater efficiency.

**Huizing, H. C.** Audiogram, Fenestration and Prosthesis, *Nederl tijdschr v geneesk* 91.12, 1947

The audiogram is of great importance as indicating whether there is any necessity of fenestration in cases of otosclerosis. When bone conduction has decreased more than 25 decibels in the speech range, no operation should be carried out, and when air conduction has decreased more than 55 decibels (except in the incipient stage of otosclerosis) in deafness due to disease of the middle ear an air conduction hearing aid with uniform amplification is indicated. In cases of inner ear deafness several types of audiograms were followed. When there is a uniform loss of hearing for all sounds, as well as when there is deafness of the abrupt type, a hearing aid with adjusted characteristics should be prescribed.

**Hutchinson, C. A.** Labyrinthine Fenestration. The Present Position, *J Laryng & Otol* 61: 567, 1946

The author discusses the symptoms and the differential diagnosis of otosclerosis and reviews the historical development of the fenestration operation. He states that there are three slightly different technics in vogue: (1) the one stage transmeatal operation of Lempert and Shambaugh, (2) the two stage posterosuperior operation of Sourdille and (3) the one stage posterosuperior operation favored by Hall and him.

He feels that in the Lempert-Shambaugh operation the access and exposure are not free enough and the hemostasis less easy to secure. Sourdille now operates with the patient under local anesthesia. In

the first stage he performs a modified radical mastoidectomy and prepares the tympanomeatal flap with great care, aided by a magnifying loupe and paying particular attention to thinning the flap and trimming it to the required shape and size. He then removes the head of the malleus, but carefully conserves the incus, as he considers that doing so increases the mobility of the flap after final fenestration. The flap is then carefully placed in position and tamponed with paraffin gauze, and the incision is sutured.

Six months or so later he carries out the second stage. He reopens the incision, makes a semicircular incision in the shrunken, adherent flap posterosuperior to the prominence of the lateral semicircular canal, raises the flap so devised and rolls it forward so as fully to expose the prominence. Then, using an operating microscope and rasps of various sizes he fenestrates the semicircular canal close to the dome of the vestibule, reapplies the flap and tamponades it in place with paraffin gauze. The incision is then sutured. He does not employ irrigation or penicillin prophylaxis. Unlike certain American workers, he makes no claims to 80 per cent success but says that there is a 50 to 50 chance of success. The author thinks that he can obtain as good results with the one stage technic as with the two stage technic. If, however, adopting the two year criterion, one finds that one cannot equal Sourdille's results in a reasonable proportion of cases, it may be that one would be well advised to resort to the two stage technic.

Among the absolute contraindications of the operation he mentions otosclerotic changes which can be roentgenographically demonstrated in the bony wall of the external semicircular canal. Among the relative contraindications he mentions a low middle fossa and a forward lateral sinus, also any stage of pregnancy, because the disease is distinctly aggravated during pregnancy, and an age over 45 years.

He favors general anesthesia induced with gas-oxygen-trilene.

He uses the postauricular approach. At first a retioauricular incision is made, the periosteum elevated and the mastoid bone exposed. Then an incision is made through the membranous external meatus in the plane of the skull surface, from a point near the bottom of the posterior meatal wall, across this wall and the roof, to a point slightly beyond the junction of the roof and the anterior wall. From each end of this incision, further incisions are carried down at right angles to it to points just short of the line of attachment of the tympanic membrane.

The subsequent steps are essentially those of Lempert's fenestra non-ovalis technic. The microscope is used for making the fistula.

The after-treatment follows the usual lines.

The causes of failure are (1) retraction of the flap (rare), (2) keloid development (very rare), (3) secondary ulceration of the flap

(4) injury of the membranous labyrinth, (5) acceleration of the otosclerotic process with degeneration of the organ of Corti (for this reason, operation during pregnancy is contraindicated), (6) failure of a hearing center, atrophic as a result of disease, to recover its function, (7) osteosclerosis, (8) serous labyrinthitis

There is a 50 to 50 chance of a permanent improvement of 25 to 35 decibels

**Jackson, M** Progressive Deafness and Its Cure, *South African M J* 21 674, 1947

The author discusses the treatment of otosclerosis and of lymphoid tissue obstruction of the eustachian tube. For the latter condition he advocates the type of irradiation recommended by Dr. Crowe, of Baltimore. He then discusses the fenestration operation, which he uses in suitable cases.

**Jones, M F** Critical Survey of the Lempert Endaural Fenestration Operation, *Laryngoscope* 57. 263, 1947

The author divides the patients into four groups: (1) ideal patients (comparatively rare), (2) good risks (satisfactory and common), (3) poor risks (few have a chance to recover some hearing), (4) unsatisfactory (occasionally operated on—after the patient has been given a thorough explanation and a period of at least three months for consideration).

There are two essentials for obtaining the best results: proper selection of patients and proper training of the surgeon. There is a place for the fenestration operation, the hearing aid and the training program in the proper care of the patient with impaired hearing. The otologist should be the one best qualified to help patients in their selection. If the patient is a good surgical risk and the operation properly done, the operation is not dangerous. Persistent dizziness is rare, transient facial paralysis may occur. A discharging ear is the most annoying postoperative feature. The operation as a rule does not result in normal hearing but in "useful" hearing.

The greatest cause of failure of the fenestration operation is bony regrowth, which closes the artificial window. Wrong diagnosis is a close second. Surgical accidents are another cause. Infection is still another.

Standards for reporting have been proposed. The standard accepted by most otologists is the 30 decibel loss level for the three conversational frequencies. It is safe to assume that a hearing improvement maintained for two years will be permanent.

Jones, M. F. Symposium on Fenestration of Labyrinth General Correlation, *Arch Otolaryng* 46: 544 (Oct ) 1947

Osteogenic closure of the fistula still remains a major cause of failure. The two methods employed by Lempert to prevent closure still hold some promise of success. These two methods may still be considered as in the experimental stage. Use of a lead burr appears to be a method of preventing closure, but lead may have other, deleterious effects. Lead is not an inert substance, and lead particles remain after the burr is used. It should not be recommended for general use at this time. In other hands than Lempert's the use of the stopple has not produced satisfactory results.

Bleeding is one of the factors contributing to bony regrowth. The author was unable to obtain a blood-free field consistently with any type of general anesthesia. However, this is achieved with the type of local anesthesia employed by Lempert and Branover. He considered it safe in the hands of these authors but does not share their feeling that it is safe in the hands of most operators.

The percentage of successful operations varies between 38 and 95 per cent for surgeons of equal ability. It seems inadvisable to state a definite percentage, but the author feels that there is a permanent improvement of hearing in more than 50 per cent.

The present standard of reporting is unsatisfactory, but it is the best so far proffered. It would be desirable to have some standard of reporting approved by the American Otological Society.

Whereas Day recommends a short postoperative confinement to bed, the author finds much less tendency toward vestibular disturbances and their consequences when the patient remains in bed and quiet for a longer time.

Training methods for the development of understanding and capable fenestration surgeons should be subject to the approval of authoritative bodies.

As a protection of the public, certification of those qualified in fenestration surgery should be implemented by the American Board of Otolaryngology at once.

The author takes exception to the statement of Maxwell "The performance of the fenestration as a surgical experiment is a violation of the ethical conception of the profession." He hopes that Maxwell will consider the implications of such a statement when applied to all innovations in medicine and especially when applied to fenestration surgery.

Kelemen, G. Fenestration of the Labyrinth. A Bibliography, *Laryngoscope* 58: 74 1948

**Kopetzky, S J** Evaluation of the Fenestration Operation in Otosclerosis, *Nebraska M J* 32 53, 1947

Patients who are to undergo the fenestration operation should be told the whole truth regarding the uncertainty of any prediction of the outcome. They should not be misled by having statistical figures quoted to them, for there is no known means by which the surgeon can truthfully tell whether in a given case the result will be a success or a failure.

On the basis of the findings of Grunert (1896, 1897) the author believes that in two thirds of the cases the round window and the acoustic nerve are involved in addition to the stapes and the oval window. In these cases the operation cannot improve the hearing.

Too many patients with a rationalized diagnosis of "clinical otosclerosis" are operated on before the diagnosis is definitely established. More stringent criteria should be used and in questionable cases medical therapy tried.

As a procedure the fenestration operation has a place in otologic surgery. However, the operation must still be classified as in the evolutionary stage. The question whether it is a valuable means of improving impaired hearing is at this time much unsettled.

A postoperative period longer than two years will become increasingly necessary before one may finally determine whether or not further evolution of the otosclerotic lesion will not bring with it further deterioration of hearing. In view of the shock entailed by a failure to attain expected results a careful preoperative psychiatric examination of the patient should be undertaken, to eliminate postoperative psychiatric breakdown.

**Kranz, F W** A Report on the Fenestration Operation, Elmsford, N J Sonotone Corporation, 1946

The author reviews for laymen the present status of the fenestration operation.

The benefits which are obtained from this window operation in some cases are not to be minimized and it seems probable that improvements in technique will increase somewhat the proportion of cases which will be benefitted. However, it does seem desirable to recognize as clearly as possible where this operation fits into the general problem of the treatment of the hard of hearing, and to recognize that only a minor group of hard of hearing people are suitable candidates for the operation, and that the operation is successful in only a percentage of the cases which are operated on. This operation has its legitimate place in the treatment of the hard of hearing but it appears that it does not appreciably change the status of the well fitted modern hearing instruments as a means for the restoration of hearing.

Lempert, J Lempert Fenestra Nov-Ovalis Operation for the Restoration of Serviceable Unaided Hearing in Patients with Clinical Otosclerosis Its Present Evolutionary Status, *Arch Otolaryng* 46 478 (Oct) 1947

Despite progress in the fenestration technic, two questions remain unanswered

1 Will the patient's acuity of hearing be improved to the level necessary to insure practical, serviceable unaided hearing for both social and economic contacts?

2 If the hearing is improved to the "serviceable" level, will it remain at that high level permanently?

Although with the tests available at present one can in the majority of cases determine preoperatively the likelihood of restoring serviceable hearing as a result of fenestration, these tests, being subjective, are not always infallible

The author feels that otologists still have no better method of determining the degree of function of the cochlear nerve in conduction deafness than the careful and intelligent use of the 512, 1024 and 2048 steel tuning forks, he suggests the following test The patient must face the examiner with chin up and eyes widely open Synchronously with the cessation of the hearing of the fork by bone conduction the eyes deviate involuntarily to the side and in the direction of the fork This deviation of the eyes is due to the patient's search for the sound which he has just lost

Although, owing to the advances made in the fenestration technic in the last ten years a large percentage of the newly created fenestras have remained permanently open, otologists have no way of knowing in advance which ones will remain patent

The author reviews all his endeavors to improve fenestration technic from 1938 to 1947

Attempts to prevent locally osteogenesis in the newly created fenestra were made on the following two surgical principles 1 Physical impedance must be offered to the osteogenesis that starts and spreads from the normal freshly cut periosteal, enchondral and endosteal layers of the fenestral rim, and thus force the same to heal without osteogenetic repair 2 The histologic structure responsible for osteogenesis within the freshly cut margins of the three layers of the bony fenestral rim must be devitalized and inactivated without being destroyed

With regard to the first principle he states that pressing the tympanomeatal flap tightly into the fistula ("soft tissue impedance") does not necessarily prevent the closure of the fistula The adhesions that may develop between the membranous labyrinth and the tympanomeatal flap are not a means of preventing osteogenetic closure of the newly cre-



ated fenestra as assumed by Lindsay, but are a result encountered occasionally because, for some unknown reason, osteogenesis did not take place

An inert metal frame obturator fitted into the bony rim of the fistula could prevent osteogenesis, but its use will remain impracticable until a method of creating a fenestra of standard size and shape is developed, so that a prefabricated frame can be used

A properly fitted cartilage stopple will prevent osteogenesis, but fibrous adhesions between the stopple and the margin of the fenestra might render the stopple immobile

The use of perforated, tightly fitting stopples is inadvisable, because the opening in the center cannot be made large enough to permit sufficient mobilization of the perilymph and the endolymph by air-borne sound. The only hope of reaching the desired objective with the stopple lies in a two stage technic—in forcing healing without osteogenesis by tightly inserting the stopple, then removing the stopple and covering the fistula with a tympanomeatal flap

In the attempt to prevent osteogenesis by the second principle controlled experiments were made in monkeys, in which the walls of the fenestras were burnished with various substances, such as steel, gold, silver, silver amalgam and pure lead. The only fistulas which stayed open were those in which the freshly cut walls were burnished with lead

The author now uses the lead technic continually. He hopes that time will prove that all the surgical problems heretofore encountered can now be successfully solved. Lead burnishing is evidently not injurious to the endolymphatic labyrinth or to the organ of Corti. In 3 patients operated on with this technic more than five years ago, the fistula has remained open and the original improvement of hearing has been maintained. If microphone amplification greatly improves the hearing of speech, the chances are that a fenestra nov-ovalis will do likewise

**Lempert, J , Meltzer, P E , Schall, L A , and Wolff, D** Osteogenesis Following Fenestration of the Vestibular Labyrinth of the Rhesus Monkey. A Controlled Experimental Study, *Arch Otolaryng* 46 512 (Oct ) 1947

Osteogenetic repair of fenestras newly created in the vestibules of the labyrinths of the rhesus monkey and its prevention were studied. Forty-one monkeys (82 ears) were operated on

Bone regeneration is initiated by fibrosis which fills up the middle ear, crossing over the fenestra at first and later filling in the fenestra. The periosteal bone is the first to regenerate in the untreated ear

After this more or less simultaneously and independently, endosteal bone, bone deposited by accretion around fragments of mature bone, and islands of newly deposited bone appear

There is no evidence that enchondral bone is immune to regeneration. Enchondral bone was observed to regenerate in some of the experimental and control ears and not in others. The size of the fenestra seems to have no bearing on the ultimate regeneration of bone.

Burnishing the freshly cut rim of the fenestra with 24 carat gold, silver, silver amalgam or stainless steel, with 2 per cent aqueous solution of gentian violet, or with electrocoagulating current did not prevent bone regeneration. Burnishing with pure lead, in 2 monkeys, prevented bone regeneration (autopsies made after six months and twenty-eight days).

Regeneration did not occur when a cartilage stopple was fitted firmly against the cut edge of the capsule.

Fibrin foam or film does not prevent regeneration. The skin flap laid over the window does not prevent endosteal bone from forming beneath it or even periosteal bone from creeping under it and crossing the window.

Lempert, J., Wever, E. G., and Lawrence, M. The Cochleogram and Its Clinical Application. A Preliminary Report, *Arch Otolaryng* 45: 61 (Jan.) 1947.

In order to determine whether a case of otosclerosis is suitable for the fenestration operation, one must have an objective test by which to recognize preoperatively the existing reservoir of cochlear function in a deafened ear. The authors report their preliminary experiments which have the goal of developing a standardized cochleogram so that any deviation from the normal can eventually be studied and recognized.

Electrical potentials arising in the cochlea in response to sounds have been observed in a great variety of experimental animals and probably arise in the hair cells of the organ of Corti. In man a cochlear response of similar character has been observed.

The authors studied the responses in 11 cases in the course of operating for otosclerosis, tinnitus or Ménière's disease. With the electrode inserted in the round window niche and probably in contact with the membrane, clearly positive responses were observed coming from 4 ears and faint responses from 2 ears. The remaining ears yielded negative results probably because of failure of the electrode to make contact with the round window membrane. Other placements occasionally tried, at the edge of the niche, on the promontory and at the newly opened fenestra in the region of the ampulla of the horizontal canal were unsatisfactory.

Lindsay, J. R. Healing of Experimental Labyrinthine Fistulas. Further Observations. *Arch Otolaryng* 46: 584 (Nov.) 1947.

The experiments were carried out in monkeys.

The interpretation based on the previous experiments, that success in maintaining a patent fenestra in a semicircular canal is dependent on the degree to which the membranous canal is preserved in its normal position at the outer periphery of the bony canal where it is free to come into direct contact with whatever covering may be used over the fistula, appears to be supported

A factor contributing to the successful application of a covering flap consists in locating the fistula on the convex surface of the mound formed by the wall of the horizontal canal slightly distal to the ampulla

In monkeys several types of flap have been utilized to prevent bony closure, with varying degrees of success (a) A conjunctival graft with epithelium outward was successfully employed (b) Thiersch grafts were used successfully in several instances (c) Grafts of the thin skin and periosteum of the wall of the external auditory meatus proved preferable to Thiersch grafts (d) The tympanomeatal pedicle flap used in the Lempert operation was the most successful covering tried in the monkey

Absence of bony closure of a fistula has been obtained in 2 patients without the application of any covering In each patient the fistula was made, after a complete simple mastoidectomy, without interfering with the drum membrane, the middle ear or the ossicular chain

In the first patient, at reoperation after about fifteen months, the fistula was found covered by mucoperiosteum The ability to limit osteogenesis is not a characteristic only of the epidermis The same result has been obtained with conjunctiva and with mucoperiosteum under suitable conditions

The degree to which an epidermal flap or graft is effective in preventing osteogenesis between it and the bony surface underneath appears to depend on the maintenance of close apposition

In the 2 patients the same forces which accounted for the repneumatization of the mastoidectomy cavity seem to have contributed to the prevention of osteogenetic closure while the mucoperiosteum was growing across the fistula

**Lindsay, J R** The Fenestration Operation Observations on the Evaluation of Hearing Tests, *Laryngoscope* 57 367, 1947

The author's summary follows

Complete closure of the fenestra after the Lempert nov-ovalis operation has become an infrequent complication

A decrease in the hearing improvement for low frequencies in the third to the sixth month is common and is evident in many cases which may still be classed as successful results

Hearing for the 2,048 and 4,096 frequencies is most consistently maintained after operation This region is most important for speech perception

A comparison between preoperative bone conduction thresholds, and the maximum postoperative hearing gain has shown a close correlation

The possibility for improvement in speech perception appears to be most accurately indicated by the preoperative bone conduction threshold values at 2,048 and 1,024 cycles

Marvil, J E Problem of Deafness, *Delaware State M J* 19:189, 1947

Marvil discusses the various types of deafness and their treatment for general practitioners

Maxwell, J H Training of Surgeon and Selection of Patient for the Fenestration Operation, *Arch Otolaryng* 46:539 (Oct) 1947

The prerequisite training of the surgeon should include first of all a wide background of diagnostic and surgical experience in the general field of otolaryngology and a thorough knowledge of the entire problem in all its phases. He should operate on cadavers under supervision, and he should observe experienced surgeons perform the operation. If it can be made practicable, it would be well for the national societies to elect a rotating board of otologists to determine the qualifications and to issue certificates of proficiency in this field.

There is considerable latitude in the selection of patients suitable for the fenestration operation.

In cases in which the presence of clinical otosclerosis can be assumed, the age of the patient and the rate of progress of the impairment should be considered. The operation is indicated in young patients with fast progressing impairment. Three or four audiograms should be taken, and the hearing threshold checked by tuning fork tests. The chief value of the tuning fork tests is to check the audiogram, which on many occasions is found to be inaccurate in spite of frequent calibration of the audiometer. Testing of speech reception is most important. The present tendency to conclude that a patient is handicapped or that the fenestration has not been successful if slightly more than a 30 decibel loss has been recorded on the audiogram for just one or even two of the tones seems absurd.

If a patient has been rehabilitated by fenestration so that he can carry on normal group conversation, the operation must be regarded as successful even though in some instances there may be a loss of 70 decibels for one or possibly two of the frequencies.

No patient is suitable for fenestration unless it can be shown by accepted tests that there is sufficient cochlear function to permit the hearing to be restored to a serviceable level through the successful by-passing of the obstructive element. The performing of the fenestration operation as a surgical experiment is a violation of the ethical concepts of the medical profession.

Mayer, O On the Cause of New Formation of Bone in the Basal Turn of the Scala Tympani in Otosclerosis, *Monatschr f Ohrenh* 81 113, 1947

The bone tissue which in patients with excessive otosclerotic areas is sometimes formed in the basal turn of the scala tympani extends from the inner surface of the promontory across the lumen of the scala to the cochlear capsule. The bone shows a very primitive structure. The author thinks that the newly formed bone represents a functional structure which tends to buttress the extensively involved capsule and to prevent its threatening collapse. The histologic changes are similar to those in bone regeneration (callus formation).

Meltzer, P E Revision of the Fenestration Operation, *Arch Otolaryng* 46 528 (Oct) 1947

Accidents excluded, osteogenesis, fibrosis and labyrinthitis, in this order of importance, are the causes of postoperative failure.

The new bone is easily distinguished from the surrounding bone during the first year or two, later it may become indistinguishable. In some cases marked tissue repair will lead to bony closure even if the operative technic has been faultless.

If the fistula has been well made, 4 to 4.5 mm long, 1.5 mm wide, with no endosteal shreds and with bone debris and chips thoroughly removed from the cavity, it should not be revised under the following conditions: if there was no improvement of hearing after the operation or if the hearing did not reach the practical level at any time, if the hearing did not reach the practical level in the speech frequencies, if the improvement of hearing was lost rapidly within three to six weeks. The last event usually means fibrosis.

A revision should be made if the original fistula was too small. It should be made if the improvement of hearing remains for six to eight weeks and is then rapidly lost, and one has a feeling that a fragment of bone might have made its way into the window or that a spicule of bone was attached to the canal wall membrane. In these instances one might revise sooner than usual, provided the cavity is clean and well epidermized.

The best time for revision of the fistula is usually from six to twelve months after it has become evident clinically that the fenestra has closed.

If during reoperation it seems difficult to expose the perilymphatic space and there is fear that further instrumentation will result in damage of the membranous labyrinth, one should stop the procedure and replace the flap over the fenestra. On elevation of the flap one may find fibrous tissue extending into the window, or the perilymphatic space may be

filled with organized material. Attempted removal will generally evulse the membranous labyrinth.

The number of cases in which hearing is improved by revision is small, about 20 to 25 per cent in well selected cases. In 15 to 20 per cent it may be improved but not to the practical level.

The danger of the hearing being made worse by revision is much greater than at the time of the original operation. It is necessary to exercise good judgment as to when not to tinker unnecessarily at the time of revision.

**Moorhead, R. L.** Fenestration for Otosclerosis. Report of One Hundred and Twenty-Three Cases, *Arch Otolaryng* 45: 49 (Jan) 1947.

The author reviews the results obtained in 123 consecutive cases seven months to four years after operation.

There are three groups of patients in whom the operation is performed: (1) those with good hearing for bone-conducted sounds, (2) those with marked nerve degeneration which has not, however, progressed to a sufficient degree to warrant the assumption that no improvement of hearing will be obtained, (3) patients with an unfavorable degree of nerve degeneration "who wish to take the chance, or on whom the otologist wishes to operate for one reason or another." Operation is perfectly justified in this last class for, if it is properly performed, even if no improvement of hearing is obtained, these patients are in no way worse off than before the operation.

There were no deaths in the whole series. Transient facial paralysis occurred in 2 patients, postoperative perichondritis, in 1. There were none in whom vertigo persisted. In about 10 per cent of the patients the cavity continued to discharge.

Fifty-seven of the 123 patients, or 47 per cent, recovered serviceable hearing, with threshold at the 30 decibel level or better for all the three conversational frequencies. In 19 patients, or 15 per cent, the 30 decibel level was reached or exceeded for two of the three conversational frequencies. These two groups should be classified as enjoying successful results. In the third group are 11 patients, 9 per cent, in whom the 30 decibel level was reached in only one of the frequencies. In 36 patients, 29 per cent, there was no improvement of hearing at all, but only 5 per cent had their hearing diminished below the preoperative level.

In 24 patients the cartilaginous stopple was used. The final results in these were not markedly different from those in patients operated on without it.

Nodine, E R Evaluation of the Fenestration Operation for Deafness, *J M A Alabama* 16.236, 1947

This is a short review for general practitioners

Ombrédanne, M Surgery of Deafness Fenestration in Cases of Congenital Atresia of the External Canal, *Oto-rhino-laryng internat Lyons* 31:229, 1947

The author reports 2 cases in which fenestration of the ampullated end of the horizontal canal and covering of the fenestra with a flap from the retroauricular region produced a remarkable improvement of hearing

Passe, E R G Bilateral Clinical Otosclerosis Treated by the Fenestration Operation Using the Cartilage Stopple and the Endaural Approach, *Proc Roy Soc Med* 40 319, 1947

The author successfully applied the fenestra nov-ovalis technic with stopple Jacobson's nerve over the promontory was destroyed by diathermy

Passe, E R G The Fenestration Operation for Otosclerosis, *Post-Grad M J* 23: 507, 1947

For this review the author discusses the following topics

#### 1 Classification or Grouping of Patients Who Have Otosclerosis

Group 1 Those in whom clinical and audiometric examination for hearing of both pure tones and speech established beyond doubt that the reserve of cochlear function is adequate In this group 80 to 90 per cent find their hearing restored to the practical conversational level.

Group 2 Borderline patients with cochlear damage apparently so extensive that it will be necessary for the maximum improvement to be obtained if the practical hearing level is to be reached In this group success can be anticipated in 20 to 40 per cent

Group 3 In these patients the cochlear nerve has deteriorated so far that the chances of improving their hearing by operation are practically nil Occasionally, however, in such patients the hearing for the low frequencies of 256 and 512 has been restored to such an extent as to enable conversation to be heard clearly

Bone conduction, while not a decisive criterion of the state of the acoustic nerve, is frequently a great help, the former guiding level of 30 decibels for the frequencies 1024 and 2048 may now be lowered to 40 decibels

Paracusis willisiana, if present, is a most important guide to the possibility of operation If absent, it definitely excludes the patient from the benefits of the operation

The period during which deafness has been increasing is not definitely significant. The greatest acuity may be expected after operation in young persons, but successful results may also be obtained in the elderly.

Improvement of air conduction is frequently observed for a short time after a successful operation in the ear not operated on. In the ear operated on, the bone conduction is occasionally improved, but frequently it is worse.

## 2 Evolution and Execution of an Efficient Fenestration Technic

The author uses the microscope and constant irrigation. He removes more of the periosteal layer around the canal and the domed vestibule than other operators, leaving only a thin eggshell layer of endosteal bone extending from the dome of the vestibule, anteriorly, to the downward bend of the lateral semicircular canal, posteriorly, on top of this area a fenestra of almost 1 cm. is then made. No cartilage stopple is used. The flap is formed of the anterior meatal wall. It is always possible to cover the dome of the vestibule and the ampulla of the lateral canal with this thin skin, but it is not always possible to cover the prolongation of the fenestra around the bend of the lateral canal with it.

Damage to the membranous labyrinth does not prevent practical restoration of hearing. In cases of Ménière's disease, treating the patient by extraction of the lateral and superior membranous canals, after sealing off the articular ends by diathermy, did not result in further deterioration of the patient's already somewhat lessened hearing.

## 3 Institution of a Meticulous and Rigidly Aseptic After-Treatment

In order to avoid postoperative stenosis a single S-shaped endaural incision is used, which produces a flap of skin hinged posterosuperiorly, which at the end of the operation is folded back into the meatus and held up against the lower border of the temporalis muscle by means of a suture passed through the flap and the skin of the postauricular groove. An absorbable cellulose packing is used.

## 4 Notation of Follow-up Records Based on Standard Tests

## 5 Tinnitus in Relation to Otosclerosis and the Fenestration Operation

In approximately 25 per cent of the patients tinnitus is either abolished or greatly reduced. In 60 to 70 per cent it remains unaltered in intensity, but may be altered in tone. In a small percentage it may become worse for a short time. Destruction of the tympanic plexus has no effect on tinnitus. It is of use only in cases in which tinnitus is possibly due to inflammatory irritation of this plexus. Tinnitus in the patient with otosclerosis is, in the author's opinion, possibly due to spasm of branches of the internal auditory artery as well as of branches of the tympanic artery.



He has found that severance of the preganglionic fibers of  $T_1$  and  $T_2$  produces instantaneous and complete cessation of the pulsating type of tinnitus. One patient with early otosclerosis on whom stelloctomy was performed showed a marked gain in hearing with complete cessation of the tinnitus, although the hearing still continues to deteriorate and the tinnitus to persist on the side not operated on. It is still questionable whether it is desirable to perform sympathectomy on both sides or not. Up to now most of the work on the sympathetic supply of the vessels of the ear has been done on the superior or the inferior cervical ganglion, but this neglects the branches going to the vertebral artery, which are most important.

#### 6 Results of the Fenestration Operation as Compared with Those Obtained by Hearing Aid

The author stresses the superiority of the operation. Whether or not in successful cases the operation either arrests or prevents the usual nerve degeneration of otosclerosis cannot yet be answered with certainty. A careful examination of the ear not operated on has been made in a large percentage of cases in which the hearing of the fenestrated ear was improved. It has shown that slight improvement does occur, up to 10 or 15 decibels, but that this improvement is purely temporary. In none of the author's cases has it persisted for more than six months.

In the author's opinion, the critical period during which an "enchondralized fistula" may close is six months.

Passe, E. R. G. Fenestration Operation for Otosclerosis. Interim Report on One Hundred and Thirty-Six Cases, *Lancet* 1. 171-174, 1947.

The author discusses briefly the historical development of the operation and the symptoms and the diagnosis of the disease. He divides the cases into three groups (see foregoing review of Passe, E. R. G. *Post-Grad. M. J.* 23: 507, 1947).

He operates now only in cases in group I and uses Lempert's fenestra nov-ovalis technic with and without a stopple. He uses continuous irrigation according to Shambaugh. The operation is done under pentothal sodium® anesthesia after heavy premedication. Vitamin K and calcium lactate are given preoperatively. The patients get up usually on the third or the fourth day and leave the hospital on the tenth to twelfth postoperative day. Age is no contraindication, provided that the cochlear nerve still retains its function.

Passe, E. R. G. Technic of Fenestration Operation, *Proc. Roy. Soc. Med.* 40: 319 (no. 6), 1947.

A colored film is used to demonstrate the technic.

The author states that he has now given up the insertion of a cartilaginous stopple, because it does not permit as great an increase in hearing as a fistula without stopple, it does not materially reduce post-operative serous labyrinthitis, it does not necessarily prevent bony or fibrous closure of the fistula. There is the further difficulty of insertion, as well as the added risk that the membranous labyrinth might be injured during the insertion and the associated manipulations.

**Popper, O** Fenestration of the Labyrinth II Transstympanic Fenestration, *J Laryng & Otol* 61: 441, 1946

In this paper the author's purpose is to fill in and accentuate important details of his previous paper of the same year.

He uses a binocular head gear giving magnification of about  $1\frac{1}{2}$  diameters and a working distance of  $6\frac{1}{2}$  inches (16.5 cm). A detailed description of the instrument is given.

General anesthesia is used (induced with open ether, oxygen and pentothal sodium,<sup>®</sup> followed by open ether and oxygen or by intratracheal ether and oxygen, intratracheal ether and oxygen alone, continuous pentothal sodium<sup>®</sup>).

The patient's face is turned toward the surgeon, and this relative position is maintained during the operation.

He describes the operation in eight stages and illustrates each stage with colored pictures.

The author gives a hydrodynamic hypothesis for the improvement of hearing that occurs with fenestration in cases of otosclerosis. He assumes that sound is transmitted to the inner ear through the round window. The auditory ossicles and muscles are not organs of sound transmission but of accommodation and protection. A mobile normal stapes acts as an escape valve to allow for displacements or vibrations of the perilymph, excited by sound impinging on the round window. The normal stapes is able by muscular action to control and adjust the amplitude of the excursions of the perilymph.

Possibly another function of the stapes is to adjust the tension of the round window membrane by hydraulic action. A specific tension will filter out or dampen unwanted frequencies and thus accentuate, or focus on, a particular sound spectrum. This function is, in the author's opinion, the first to disappear in otosclerosis.

In fixation of the stapes the escape valve action is absent. The wave is therefore suppressed, dammed back, dampened and distorted and can, therefore, stimulate only the organ of Corti, but feebly. If the entire capsule plus the perilymph is set into vibration, hearing is good—as in bone conduction in otosclerosis.

Fenestration of the labyrinth creates a new escape valve.

The tympanic membrane has three main functions 1 It is a most perfect receptor for sound 2 It assists by variations of tension to "focus" for sound 3 It protects the organ of Corti by an immediate tympanostapedial reflex and by relaxation, curtailing and dampening sound vibrations

**Popper, O** Fenestration for Otosclerosis, *Presse méd* 54: 648, 1946

The author gives a short description of the method which is described in detail in the *Journal of Laryngology and Otology* (61 441, 1946)

**Rosen, S** Learning the Lempert Fenestration Operation, *Arch Otolaryng* 45. 335 (March) 1947

The author stresses the technical difficulty of the operation and the necessity of practicing on the cadaver and watching a great number of operations performed on the living, by competent surgeons

**Rosenberger, H C** The Fenestration Operation for Otosclerosis A Discussion and Report of Results, *Ohio State M J* 43• 1042, 1947

This is a discussion of the problem for general practitioners

Among the 32 patients operated on by the author, 12 had their hearing for the frequencies 512, 1024 and 2048 brought up to or above the 30 decibel level, 3 to the 35 decibel level and 4 to the 40 decibel level These patients are just as satisfied with the results as those whose improvement reached the 30 decibel level Nineteen patients (59 per cent) had an excellent or a good result, 8 or (25 per cent) have a fair result, which they appreciate and to which they are able to make adjustments without resorting to a hearing aid Poor results ensued in 5 (15 per cent)

One patient experienced transient facial paralysis, and 2 patients, closure of the fenestra One patient maintained an excellent improvement for eight months, then there was a rapid return to the preoperative level, coincident with pregnancy The fistula symptom remained active

**Rosenberger, H C, and Bukovina, E R N** Fenestration The Success of This Delicate Operation Depends on Expert Nursing Care as Well as Surgical Skill, *Am J Nursing* 47 730, 1947

The authors discuss the principle of the fenestration operation and certain important factors in the nursing care Every patient is a potential psychiatric problem Having been afflicted with deafness—sometimes over a prolonged period—the patients are prone to be emotionally unstable They are likely to seize on the fenestration operation with

the immoderate hopes and enthusiasm of a zealot. A thoughtless word uttered by the nurse may profoundly influence such a patient.

Postoperative care is indubitably important. The patient should lie on his back or on the ear operated on, he should be watched closely for facial paralysis.

**Salem, W.** The Fenestration Operation of Lempert for the Treatment of Deafness. Results in Seven Cases, *Rev brasil de oto-rino-laring* 15: 101, 1947.

The author reviews the literature of the last few years regarding the fenestration operation. He studies the physiologic basis of the operation and its results and reports observations concerning 7 patients whom he operated on.

The complications of the operation are reduced to the minimum, there being practically no serious postoperative complications. It is possible to obtain excellent results in 70 per cent of the cases, and with further improvement of the technic, the results might become even better.

**Salem, W.** Lempert's Fenestration Operation for the Treatment of Deafness. Results in Seven Cases, *Hospital, Rio de Janeiro* 32: 565, 1947.

**Salomon, J.** Surgery of Deafness, *Semaine d hôp Paris* 23: 182, 1947.

This is a general review.

**Shambaugh, G. E.** The Fenestration Operation. An Evaluation of Its Present Status, *Surg, Gynec & Obst* 84: 828, 1947.

The operation is useful in two types of cases: (1) the ideal case in which there are ankylosis of the stapes and normal cochlear function and the patient has an 80 per cent chance of a permanent improvement of hearing and (2) the suitable case in which the hearing by bone conduction is normal except for one of the speech frequencies and the loss for this frequency is 30 decibels or more. In this type of case the patient has a 50 per cent chance.

There are two other types of cases. There is, first, the experimental case in which tests with two or more of the speech frequencies show a 30 decibel or greater loss for bone conduction, but the Rinne test with the 1024 fork is negative. In cases of this type there is a 1 in 10 chance of sufficient improvement to give practical hearing without an aid. Then there is the unsuitable case in which impairment is due either to

incomplete fixation of the stapes or to profound nerve degeneration. In this type of case the operation is contraindicated. The worse ear should always be operated on.

In the selection of patients the following four tuning fork tests are particularly helpful:

1. If the patient cannot hear the 64 fork at maximum intensity close to the ear, the stapes may be regarded as completely ankylosed. If the fork is audible by air at moderate intensity, the fixation of the stapes is incomplete and the operation contraindicated because there is too little to be gained.

2. If the Rinne test with the 1024 fork is negative, the opposite ear being masked, the hearing should be improved by the operation even though the case is suitable but not ideal or an experimental case.

3. If the Rinne test with the 512 fork, the opposite ear being masked, shows that air conduction is better than bone conduction, the fixation of the stapes is only slight and the operation is contraindicated.

4. If the 2048 fork is not heard by bone conduction, the opposite ear being masked, the prognosis is poor.

The judgment as to which technic is the best must await the publication of adequate detailed statistical data. The author uses the fenestra nov-ovalis technic with "enchondralization," irrigation and microscope.

Two years after the operation, among 415 patients operated on, there was fully maintained improvement in 363 (81.5 per cent) and a further loss in 7 (1.7 per cent).

Among those whose hearing was improved, the 30 decibel practical level was permanently maintained in 197 (47 per cent).

The author reports the results of an inquiry concerning the improvement from the patient's point of view. Among 623 patients operated on, 82.8 per cent regarded the operation as successful in all respects, and only 10.2 per cent as a failure. Of the 516 who regarded the operation as completely successful, 303 reached the 30 decibel practical level and 71 were within 5 decibels of the practical level, while 142 had a more than 35 decibel loss for the speech frequencies. For the patient, not only the final hearing level but also the number of decibels gained is important. Most patients prefer the gain of hearing following the operation to a hearing aid. There is evidence that a successful fenestration may arrest or delay the nerve degeneration of otosclerosis in some cases, but it is too early to be certain of this.

With a meticulous aseptic technic the risks of the operation have proved to be minimal. The chief risks are those of the facial nerve.

and the labyrinth The two year hearing results of the operation may be regarded as the permanent hearing results

**Shambaugh, G E, Jr** Fenestration Operation for Otosclerosis, *Minnesota Med* 30: 1249, 1947

The author discusses briefly, for general practitioners, the principle of the fenestration operation Each patient is classified according to bone conduction hearing tests

**Sheridan, M R** Otosclerosis, *M Press* 217 56, 1947

This is a short review of the pathologic aspects and the treatment for general practitioners

**Simpson, J F.** An Operating Microscope for the Fenestration Operation, *Proc Roy Soc Med* 40: 320, 1947

The author demonstrates a microscope with three sets of eye pieces permitting magnifications of 3, 7 and 10.5 diopters

**Sourdille, M** The Surgical Problem of Otosclerosis, *Rev de laryng* 68: 481, 1947

Sourdille reviews briefly the history of the surgical treatment of otosclerosis and of the general principles of the operation There are four main difficulties

- 1 Difficulty of proper visualization of the ossicles and the labyrinth, which is overcome by the use of magnifying glasses (Gullstrand-Lupe and Zeiss binocular microscope)

- 2 Difficulty of gaining access to the middle ear and labyrinth The author uses the retroauricular approach

- 3 Suppuration of the ear operated on This can be overcome by forming and placing a tympanomeatal flap so as to close off the middle ear, by removing the pneumatic cells completely and by introducing fibromuscular transplants into the mastoidectomy cavity

- 4 Vertigo The author stresses the importance of the preservation of the nonluxated incus for the proper transmission of sound He prefers a fistula which is not too large and which is made over the lateral semicircular canal or over the lateral part of the ampullated end

**Staffieri, M** On Citelli's Tympanic Presclerosis, *Arch ital di otol* 57 125, 1946

The author reports 6 cases of "infantile presclerosis" in which remarkable improvement occurred under treatment with iodine The reduction of hearing could not be explained by middle ear changes The condition described might represent the preliminary stage of true otosclerosis, as

assumed by Citelli. This author believes that the condition is due to plastic inflammatory or dystrophic changes within the oval window niche which lead to immobilization of the stapes.

He discusses the various theories concerning the pathogenesis of otosclerosis. He thinks that the venous stasis which, according to Wittmaack, initiates the formation of the otosclerotic foci could cause the functional changes described as presclerotic by Citelli.

**Venker, J.** Some Remarks on the Fenestration Operation and What Leads to the Results, Thesis, Amsterdam, 1947, Lempert Operation in Therapy of Otosclerosis, *Nederl tijdschr v geneesk* 91: 303, 1947.

The author uses the retroauricular approach and forms the flap according to the method of Lempert and the fistula according to the method of Shambaugh.

The results obtained with the operation in 12 cases are reviewed, and the improvement of the hearing of the ear not operated on is demonstrated. This is explained with the theory of Gray concerning otosclerosis. The open fistula allows a greater volume of sound to penetrate into the cochlea, so that the stimulation of the vasomotor system becomes more intense. This unilateral stimulus exerts its effect on both ears, owing to the fact that the sympathetic fibers of both originate in plexuses around Willis' circulus arteriosus. The disappearance of the tinnitus after operation is attributed to the better blood supply. The author refutes the assumption that an increase of intralabyrinthine pressure is present in otosclerosis.

As the author, with Gray, assumes that there are disturbances of the vasomotor system in otosclerosis and that the good results of the operation are at least partly due to an improved vasomotor reflex, he suggests one should try to achieve improvement of hearing by bilateral extirpation of the stellate ganglion, as fenestration does not yield 100 per cent successful results.

A case of otosclerosis in which mastoidectomy alone was performed resulted in a considerable improvement of hearing for several weeks. This is supposed to have been due to the stimulus of the vasomotor system following trauma of the mastoid process.

**Viole, P.** The Surgical Treatment of Deafness, *Ann West Med & Surg* 1: 25, 1947.

This is a short review of the problem for the general practitioner.

**Weersma, P.** Fenestration Operation in Otosclerosis, *Nederl tijdschr v geneesk* 91: 856, 1947.

This is a review for general practitioners.

De Weese, D D Fenestration for Otosclerosis Technic and Results in Eleven Cases, *Portland Clin Bull* 1: 3, 1947

The author reports cases

Whitaker, C F, Jr ; Juers, A. L., and Shambaugh, G E A Modified Endaural Incision with Nerve Block Anesthesia for Fenestration and Mastoidectomy, *Arch Otolaryng* 45: 662 (June) 1947

The authors describe a modified incision which affords the following advantages (1) a shorter postoperative course for complete healing, (2) less tendency toward atresia of the meatus, (3) less deformity

The incision is made in two parts The first part is started on the superior wall of the external auditory canal (12 o'clock) at the junction of the bony and the cartilaginous portions of the canal It is extended posteriorly around the canal to the inferior wall (6 o'clock), care being taken to keep the incision at the same level of the canal At this point the blade is directed outward and the skin cut about 0.5 cm laterally toward the incisura The periosteum is then divided along the posterior wall of the bony part of the canal by arclike sweeps of the knife point

The second part of the incision is started at a right angle to the first part, on the superior wall of the canal (12 o'clock) It is first outlined with a knife, to avoid a jagged edge, by incising through the epidermis into the dermis This incision extends out of the canal, between the tragus and the anterior crus of the helix, about 1.5 cm along the anterior edge of the cartilage of the pinna The incision is continued deeper, and the periosteum is divided The temporal fascia, when encountered, is incised If the temporal muscle is low, it is freed from its fascial sheath and is pushed upward away from the field The periosteum is then elevated posteriorly, superiorly and inferiorly, over the mastoid process, sufficiently to provide adequate exposure The root of the zygoma is exposed and a self-retaining retractor inserted

After the operation has been completed, two sutures are placed in the superior part of the incision anterior to the helix The posterior edge of the incision is tucked under the packing into the meatus

Block anesthesia is obtained with dibucaine hydrochloride (nupercaine hydrochloride®) (1:1,500) plus 0.5 cc of epinephrine hydrochloride 1:1,000 per 30 cc The procedure anesthetizes in four steps all the nerves supplying the auricle (auriculotemporal), the auricular branch of the vagus nerve, the great auricular nerve and the lesser occipital nerve from the cervical plexus

Wilmes, M N Modern Fenestration Surgery for Otosclerosis *Hear-ing News* 15. 5, 1947

This is a discussion for laymen



# Directory of Otolaryngologic Societies \*

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Place Montevideo Time January 1950

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